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# Physics Abstracts

Volume 64 APRIL 1961 Number 760

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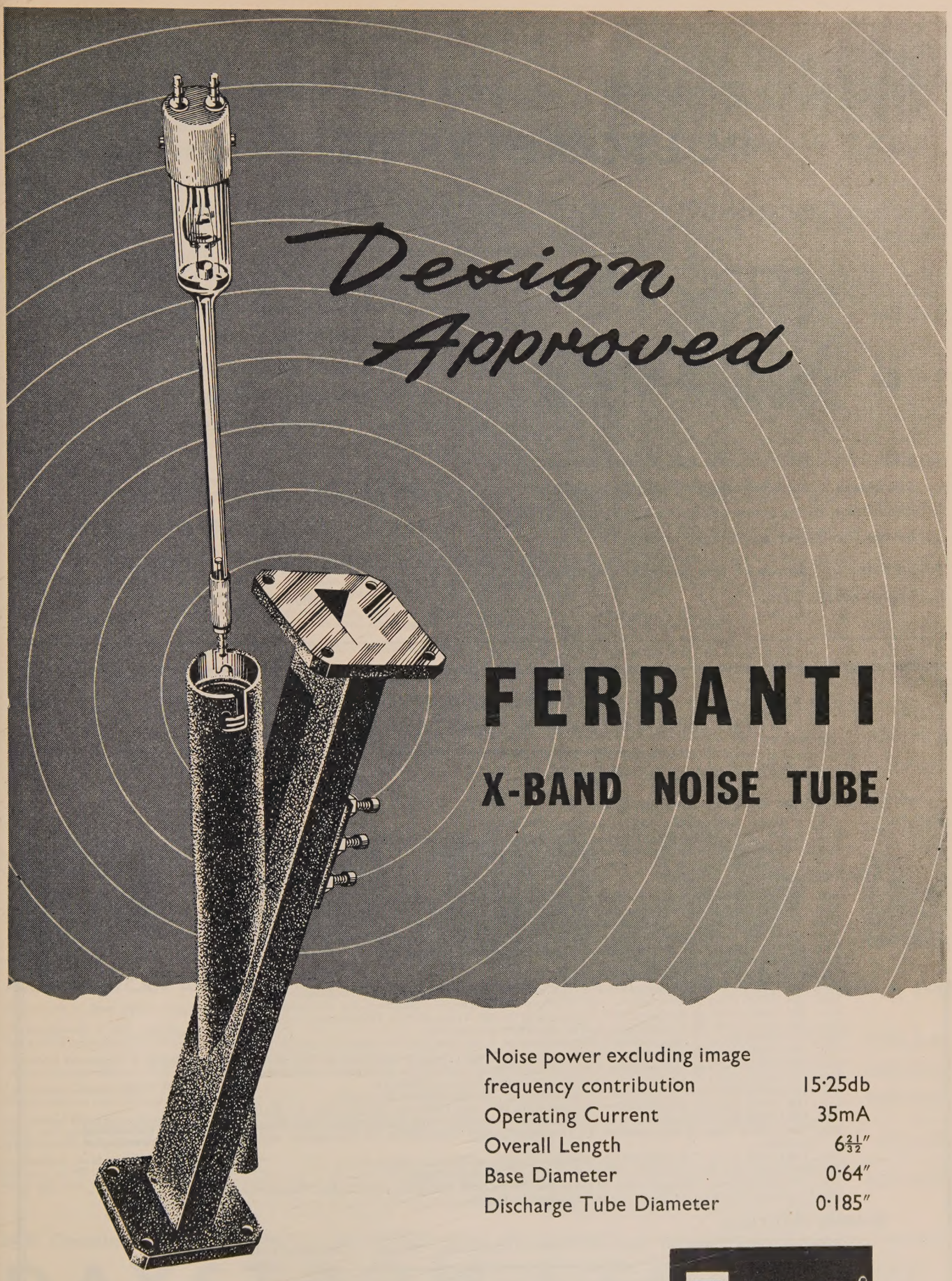

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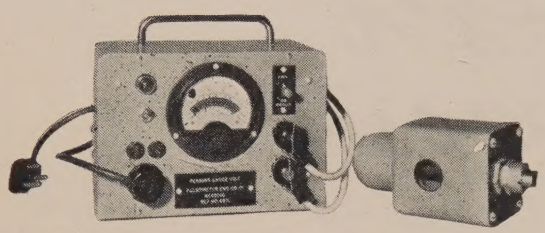

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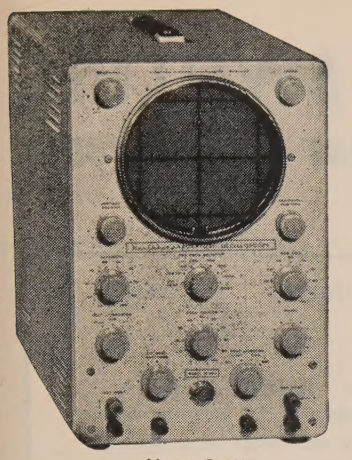

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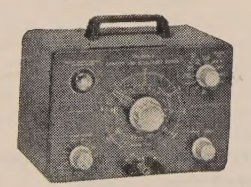
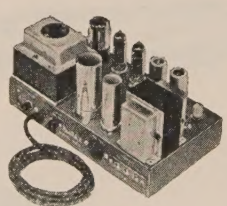
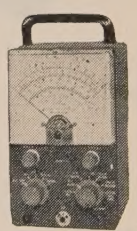


C-3U

S-3U



MA-12



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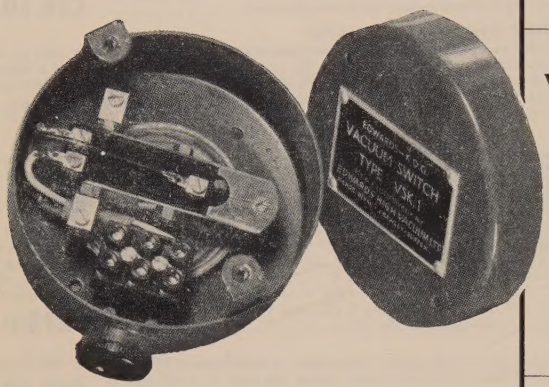


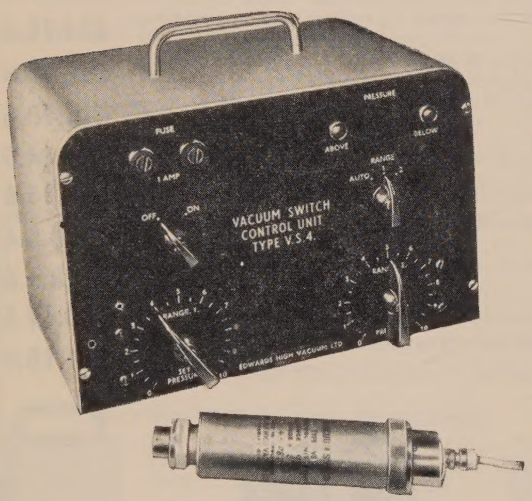


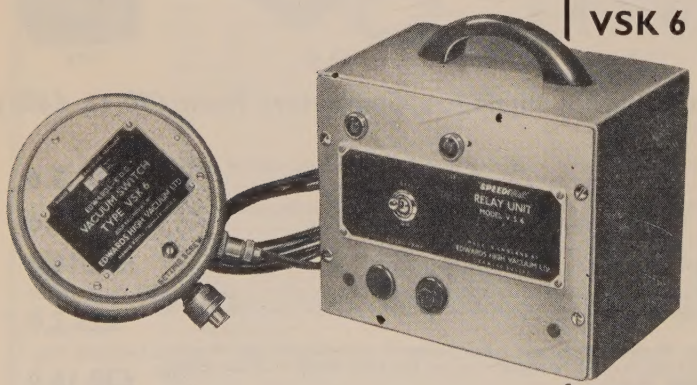


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# PHYSICS ABSTRACTS

Volume 64 APRIL 1961 Number 760

# MATHEMATICS

4169 FRONTIERS OF NUMERICAL MATHEMATICS. Edited by R.E.Langer.
Madison, Wisconsin: The University of Wisconsin Press (1960) 132 pp. [Publication Number 4 of the Mathematics Research Center, United States Army, The University of Wisconsin].

For abstracts of the papers contained in the above symposium see Abstr. 16225, 16531, 16724, 17078, 17640, 18426, 18477, 18574 of 1960.

4170 NUMERICAL TABLES OF ASSOCIATED LEGENDRE FUNCTIONS. VOLUME II. [Tables Numériques des fonctions associées de Legendre].
Paris: Editions de la Revue d'Optique (1959). In French.

For Vol. I see Abstr. 8176 of 1953. Associated functions of the first kind, $P_n^m(\cos\theta)$. This volume covers: $n = -0.5(0.1)10$; $m = 0(1)2$; $\theta = 0(1)180^\circ$. These tables are different to the preceding ones in that they include more decimal places and main differences of the second and fourth order, permitting the interpolation formula of Everett–Laplace to be used.

4171 THE SOLID ANGLE SUBTENDED BY A CYLINDER. P.G.Guest.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 164-5 (Feb., 1961).

An approximation formula for the solid angle subtended at a point by a right circular cylinder is obtained and its error evaluated. The variation in the solid angle with displacement of the point from the symmetrical plane through the centre of the cylinder at right angles to the axis is also discussed.

4172 A NOTE ON HANSEN'S VECTOR WAVE FUNCTIONS. T.B.A.Senior.
Canad. J. Phys., Vol. 38, No. 12, 1702-5 (Dec., 1960).

Hansen's method for generating solutions for vector wave-equations in terms of a separable solution of a scalar wave-equation succeeds if a suitable vector function exists, determining the vector solutions. This vector function is shown to consist, in a general co-ordinate system, of a radial vector $\bar{R}$ and a set of constant (unit) vectors. J.K.Skwirzynski

COMPLETE SYMMETRY OF SCALARS, VECTORS, AND TENSORS OF RANK TWO. See Abstr. 4008

4173 ON THE CALCULATION OF THE INVERSE OF THE OVERLAP MATRIX IN CYCLIC SYSTEMS. P.O.Löwdin, R.Pauncz and J.de Heer.
J. math. Phys. (USA), Vol. 1, No. 6, 461-7 (Nov.-Dec., 1960).

The inverse of the overlap matrix of a cyclic system is computed in three different ways, each of which throws light on a different aspect of the subject and has its own range of applicability to related problems. In all these derivations extensive use is made of the properties of the Chebyshev polynomials. The results hold for every cyclic symmetric matrix.

4174 GENERALIZATION OF THE "EDGE-OF-THE-WEDGE" THEOREM. H.Epstein.
J. math. Phys. (USA), Vol. 1, No. 6, 524-31 (Nov.-Dec., 1960).

It is proved that two analytic functions of several complex variables, having the same boundary values when the imaginary parts of the variables tend to zero inside two arbitrary, but fixed, open cones, possess a common analytic continuation in a certain open set. This is a generalization of the "edge-of-the-wedge" theorem a proof of which is obtained in passing.

4175 SYMMETRY-ADAPTED FUNCTIONS BELONGING TO THE SYMMETRIC GROUPS. H.V.McIntosh.
J. math. Phys. (USA), Vol. 1, No. 6, 453-60 (Nov.-Dec., 1960).

Young's factorization of idempotents belonging to the symmetric groups is given a necessary and sufficient characterization, by means of a lemma due to Burrow. The use of these idempotents is contrasted with Yamanouchi's representation, and finally the equivalence of Löwdin's path diagram method to the group-theoretical treatment of the angular momentum states arising from the coupling of an assemblage of spin $\frac{1}{2}$ particles is demonstrated.

4176 CONTRACTION OF LIE GROUPS. E.J.Saletan.
J. math. Phys. (USA), Vol. 2, No. 1, 1-21 (Jan.-Feb., 1961).

Contraction is defined for a Lie group to coincide on its Lie algebra with a generalization of contraction as first introduced by Inönü and Wigner. This is accomplished with a sequence of non-singular coordinate transformation on the group (or nonsingular linear coordinate transformations on its Lie algebra), whose limit is a singular one. Essentially all of the calculations are performed in the algebra. It is assumed that in the limit the association in the algebra (the multiplication law in the group) converges, and this gives a necessary and sufficient condition on the algebra. Once it is satisfied, the new (contracted) algebra is uniquely determined in terms of the original one. It is found that the contracted algebra can be further contracted in the same way, and likewise the algebra so obtained. In this way one obtains a terminating sequence of algebras. Inönü-Wigner contraction corresponds to a sequence terminating at the first contraction. Some properties of the original and contracted algebras are studied, and some specific examples are given. Contraction of a Lie algebra induces contraction of any of its representations. This is examined for the case of finite-dimensional representations. Ray representations are discussed in general. It is shown how the trivial exponent of the Lorentz group changes under contraction to the nontrivial one of the Galilei group.

4177 ON ANALYTIC CONTINUATION, MULTIPLICATION, AND FOURIER TRANSFORMATIONS OF SCHWARTZ DISTRIBUTIONS. H.J.Bremermann and L.Durand, III.
J. math. Phys. (USA), Vol. 2, No. 2, 240-58 (March-April, 1961).

The theory of distributions of Schwartz (1951) generalizes the notion of (ordinary) "function" such as to include measures and other "generalized functions". It is shown that a class of Schwartz distributions on the real axis can be continued to holomorphic functions in the upper and lower complex half-planes such that the "jump" on the real axis represents the distribution. Many operations with distributions can be reduced to operations with the associated holomorphic functions which is of particular interest for the convolution product and for Fourier transforms. By means of the continuations several kinds of multiplications for distributions are being defined, which is of interest for quantum field theory.

4178 CLASSIFICATION OF FOUR-DIMENSIONAL RIEMANNIAN SPACES. J F.Schell.
J. math. Phys. (USA), Vol. 2, No. 2, 202-6 (March-April, 1961).

A classification of four-dimensional Riemann spaces with signature +2 is given. The classification depends upon the differential as well as the algebraic properties of the Riemann tensor. The tool employed is the infinitesimal-holonomy group of the space. An introduction to the concept of the holonomy group is given, and the technique of classification is outlined. A comparison with the classification of empty spaces given by Petrov (1954) and with the recent work of Newman (1961) is also given.

4179 A CLOSED GENERAL SOLUTION OF THE PROBABILITY DISTRIBUTION FUNCTION FOR THREE-DIMENSIONAL RANDOM WALK PROCESSES.
Chi-hua Hsiung, Hsien-chih Hsiung and A.A.Gordus.
J. chem. Phys (USA), Vol. 34, No. 2, 535-46 (Feb., 1961).

A closed general solution is derived and in addition: (1) For the particular case of equal-length displacements, the exact solution is compared with the Gaussian approximation for n = 3, 5, and 10 steps. (2) The general solution is utilized in calculating the probability distribution of gamma-ray energies resulting in the $Cl^{35}(n,\gamma)Cl^{36}$ process. (3) For five unequal steps of fractional length: 0.582, 0.135, 0.131, 0.092 and 0.060 (which is somewhat characteristic of the fractional energies of gamma-rays resulting from neutron capture), the exact solution is compared with a Gaussian, a modified Gaussian, and a five equal-step approximation. (4) There are presented the specific solutions for all possible unequal-length random displacements involving n = 2, 3, and 4 steps.

4180 STOCHASTIC PROCESSES. PROBLEMS AND SOLUTIONS. L.Takács (Translation from Hungarian by P.Zádor.)
London: Methuen and Company; New York: John Wiley and Sons (1960) xi + 137 pp.

A collection of a large number of results. Some theorems are stated without proof, while others are presented as problems whose solutions are outlined in the final chapter. Chapter 1 deals with Markov chains, Chapter 2 with Markov processes, that is to say, with the history of systems whose states are completely fixed by their states at the immediately preceding instant of time. Chapter 3 is more advanced and deals with various examples of non-Markovian processes, recurrent processes, stationary stochastic processes and secondary stochastic processes. It is stated that the material in Chapters 1 and 2 is available in textbooks, but that in Chapter 3 is nearly all from original papers. Chapter 4 outlines the solutions of all the problems. This book will be a very valuable work of reference, but has the minor defect that proofs of some of the theorems may, in practice, be difficult to trace. In addition, the applications of certain of the results are not made clear, e.g. Kolmogorov's two systems of differential equations, so that the reader is uncertain whether they are merely of mathematical interest, or whether they are of value in solving actual problems. 60 references. H.N.V.Temperley

4181 TRANSISTORIZED ELECTRONIC ANALOG MULTIPLIER. S.Deb and J.K.Sen.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 189-92 (Feb., 1961).

The exponential current–voltage characteristic of the input of a grounded base junction transistor is utilized to construct an analogue multiplier. Four-quadrant operation is obtained by using two channels — one with pnp and the other with npn transistors. Design considerations of the various components of the multiplier are discussed. It is shown that the performance of the multiplier — particularly in respect of bandwidth — compares favourably with that of the other types described in the literature.

ANALOGUE METHOD FOR COMPUTING THE NUMBER OF SPINS CONTRIBUTING TO A MAGNETIC RESONANCE ABSORPTION. See Abstr. 4739

4182 DOMINO RULE. A WAY OF HANDLING RELATIVE VELOCITIES. J W.Dewdney.
Amer. J. Phys., Vol. 29, No. 4, 249-51 (April, 1961).

Relative velocities can be combined in a way similar to the positioning of dominoes in the parlour game. The advantage of this method over the more usual one involving addition or subtraction of vectors is that it is more intuitive. It is particularly useful in the transition between laboratory and centre of mass coordinate systems.

COMPUTER FOR THE CONVERSION OF TRISTIMULUS VALUES TO TRICHROMATIC COEFFICIENTS. See Abstr. 4160

4183 UNI-AXIAL PANTOGRAPH. J.C.Barnes.
J. sci. Instrum. (GB), Vol. 38, No. 3, 94-5 (March, 1961).

A description is given of a simple and effective drafting instrument for changing the scale of a graphical trace along one axis only, leaving the other axis unaltered.

# ASTROPHYSICS

4184 SOME PHOTOMETRIC CHARACTERISTICS OF THE CAPE VICTORIA REFRACTORS.
J.D.Fernie and W.J.Rosenberg.
Monthly Notes Astron. Soc. S. Africa, Vol. 19, No. 11, 173-5 (1960).

Calibration curves for the 18 and 24 in. refractors are given, showing the relationship between exposure and stellar magnitude. R.W.Fish

MAKSUTOV-CASSEGRAIN OPTICAL SYSTEM FOR ASTRONOMICAL PURPOSES. See Abstr. 4446

4185 VARIATION OF PARAMETERS FOR ELLIPTIC AND NEAR CIRCULAR ORBITS. S.Pines.
Astron. J. (USA), Vol. 66, No. 1, 5-7 (Feb., 1961).

The classical parameters used in the variation of constants for the special perturbation techniques in celestial mechanics present basic difficulties for orbits of small eccentricity and low inclination. In addition these methods require the solution of a differential equation for the integration of the mean anomaly using some form of Kepler's equation. A method is presented herein which avoids the ambiguities for near circular and low inclination orbits, and avoids the need of an additional equation for the integration of the mean motion. The method uses as parameters a set of initial position and velocity vectors in the osculating orbit plane.

4186 THE REDUCTION FROM GEOCENTRIC TO GEODETIC COORDINATES. J.Morrison and S.Pines.
Astron. J. (USA), Vol. 66, No. 1, 15-16 (Feb., 1961).

The equations relating these coordinate systems require the solution of an eighth-order polynomial. The method outlined herein avoids an iterative procedure for solving these equations by providing a closed-form explicit solution using the Lagrange expansion formula.

4187 ON THE RELATION BETWEEN LUMINOSITY DISTANCE AND DOPPLER SHIFT IN RELATIVISTIC COSMOLOGY.
R.van der Borght.
Austral. J. Phys., Vol. 13, No. 3, 602-5 (Sept., 1960).

The luminosity distance D is expressed as $(R_0^2/R)f(\psi)$, where $f(\psi)$ is $\sin\psi$, $\psi$ or $\sinh\psi$ for elliptic, flat or hyperbolic space, and $\psi = c\int_R^{R_0}(RR)^{-1}dR$. The series expansion of $f(\psi)$ provides a simplified derivation of the relation between D and the Doppler shift $\delta$. This relation is given up to terms involving $\delta^3$. R.A.Newing

4188 OBSERVATIONAL TESTS IN COSMOLOGY (44TH GUTHRIE LECTURE). F.Hoyle.
Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 1-16 (Jan., 1961).

Cosmologies separate sharply into those which predict that a definite origin of the whole universe occurred a precise finite time ago, and those which require no such origin to have taken place. Observational methods exist for arriving at a decision between these two forms of theory. In particular, these are: (i) Geometrical tests: Proposed differences between the present state of the universe (determined by the observer's immediate locality) and the past condition of the universe (determined by observation of very distant objects) are investigated under this heading. (ii) Local evolutionary tests: The past history of the universe must have been such as to lead to the present state. When applied to the formation of galaxies, the ages of galaxies, to the generation of cosmic rays and cosmic radio waves, this simple condition turns out to have far-reaching implications. The current status of tests under these headings is reviewed.

4189 THE GRAVITATIONAL FIELD OF THE EARTH DERIVED FROM MOTIONS OF THREE SATELLITES. Y.Kozai.
Astron. J. (USA), Vol. 66, No. 1, 8-10 (Feb., 1961).

Coefficients of the second, third, fourth, and fifth harmonics of the earth gravitational field are determined from analysis of motions of three artificial satellites, 1958 β2, 1959 η, and 1959 ι1, as follows:

$A_2/a_e^2 = (1.623\,29 \pm 0.000\,04) \times 10^{-3}$, $A_4/a_e^4 = (9.3 \pm 0.2) \times 10^{-6}$,
$A_3/a_e^3 = (2.29 \pm 0.02) \times 10^{-6}$, $A_5/a_e^5 = (2.3 \pm 0.2) \times 10^{-7}$

4190 MERIDIAN OBSERVATIONS OF THE MOON, 1956-59. A.N.Adams and S.M.Bestul.
Astron. J. (USA), Vol. 66, No. 1, 36 (Feb., 1961).

Latitude and longitude residuals from Ephemeris lunar positions are given for the lunations of 1958-59.

4191 DATING LUNAR SURFACE FEATURES BY USING CRATER FREQUENCIES. T.J.Kreiter.
Publ. Astron. Soc. Pacific (USA), Vol. 72, 393-8 (Oct., 1960).

Using crater counts (number of craters of a given diameter per sq. km of lunar surface) derived from Wilkins' 300 in. map, and Mt. Wilson 100 in. photographs in both continental (undisturbed) and Mare Imbrium regions, an approximate age for the latter feature has been deduced from the integrated frequency curves. Diameters of ~900 craters were measured in the continental area selected, and of more than 1000 craters in the Mare region. The following empirical relation was found: age of Mare Imbrium $= 4.5 \times 10^9 (N_{Imb}/N_{con})$ yr, where $N_{Imb}$ and $N_{con}$ are the respective integrated frequency counts for the two regions under examination. This yields an age of between 1 and $5 \times 10^8$ yr for the Mare Imbrium, as compared with Urey's estimate of 3 to $4.5 \times 10^9$ yr (1956), and Kuiper's more recent value of $\sim 3.5 \times 10^9$ yr (1959). D.R.Barber

4192 TRANSIT OF MERCURY OBSERVED AT AUSTIN, TEXAS. G.de Vaucouleurs.
Astron. J. (USA), Vol. 66, No. 1, 36 (Feb., 1961).

Third- and fourth-contact times of Mercury's November 7, 1960 transit were observed, with probable errors less than 1 sec.

4193 OBSERVATIONS OF THE PLANETS JUPITER AND SATURN IN 1960. J.H.Botham.
Monthly Notes Astron. Soc. S.Africa, Vol. 19, No. 11, 175-7 (1960).

Estimated brightness values (visual and photographic) are given for major features of the two planets. The observations were made with the 9 in. Grubb refractor of the Union Observatory, Johannesburg, from February to September, 1960. D.R.Barber

4194 COMET NOTES. M.P.Candy.
J. Brit. Astron. Assoc., Vol. 71, No. 1, 32-3 (Jan., 1961).

A summary of visual and photographic observations, by B.A.A. members, of 6 comets appearing in 1960, one of which (Comet Burnham, 1959k) attained a maximum brightness of $4^m.0$ in late April. Details of a further 8 periodic comets recovered during 1960 are tabulated. D.R.Barber

4195 MOLECULAR NITROGEN IN THE SPECTRA OF TWO PERSEID METEORS. J.A.Russell.
Publ. Astron. Soc. Pacific (USA), Vol. 72, 291-5 (Aug., 1960).

Bands of the $N_2$ first positive system are identified between 6372 and 6603 A in the spectra of two Perseid meteors. It is suggested that apparent vagaries in their intensity distribution may be due to physical conditions of the atmosphere and solar activity. R.W.Nicholls

4196 PHOTOMETRY OF THE ZODIACAL LIGHT. R.Robley.
C.R.Acad. Sci. (France), Vol. 251, No. 25, 2883-5 (Dec. 19, 1960). In French.

With the aid of interference filters and a Lallemand photomultiplier photometer, the absolute intensity of the Z.L. was measured at 4630, 5280 and 6165 A, in 15 steps out to an angular distance of 60° from the sun. At 35° heliocentric distance, absolute values (in units of $10^{-7}$ erg $sec^{-1}$ $cm^{-2}$ $sterad^{-1}$ $A^{-1}$) of 29.4, 34.4 and 35.3 are found at the respective wavelengths, and at 60° the corresponding values are 9.2, 14.4 and 16.3 D.R.Barber

4197 SOLAR ACTIVITY DURING 1959. F.Addey.
J. Brit. Astron. Assoc., Vol. 71, No. 1, 24-7 (Jan., 1961).

The report summarizes the work of 19 B.A.A. solar observers through the period 3 January to 22 December 1959, when 348 days were utilized. Sunspot activity, as measured by 5-rotation running averages of mean daily frequency of active areas per rotation, showed a $1\frac{1}{4}$ yr periodicity superposed on the usual trend in activity due to the 11 yr cycle. Asymmetric distribution of active areas between N and S hemispheres was more conspicuous than in the previous year. As in former years from 1955 onwards, the more active hemisphere was also that in which the mean heliographic latitude of sunspot areas was the greater. D.R.Barber

4198 VELOCITY VARIATION OF LEADER SUNSPOTS WITHIN THE SOLAR CYCLE. R.A.Miller.
Publ. Astron. Soc. Pacific (USA), Vol. 72, 399-402 (Oct., 1960).

Rotation rates for 365 leader spots, selected from 1621 sunspot groups observed at Mt. Wilson Observatory during the years 1917-25, have been computed and corrected for the dependence of rotational velocity on heliographic latitude using Newton's relationship (1934). A well-marked trend in relation to the solar magnetic cycle is found. To account for this it is suggested that at spot maximum the higher latitude spots are dragged along by a stronger magnetic coupling with the motion in equatorial regions than is operative at later phases of the cycle. D.R.Barber

4199 THE EXCITATION OF THE RED CORONAL LINE λ 6374. C.Pecker.
C.R. Acad. Sci. (France), Vol. 251, No. 18, 1862-4 (Oct. 31, 1960). In French.

A kinetic analysis is made of the influence of the $^2S_{1/2}(3s3p^6)$ level upon the population of the $^2P^0_{1/2}(3s^23p^5)$ state from which the 6374 A coronal line ($^2P^0_{1/2} - {}^2P^0_{3/2}$) of Fe X is emitted. R.W.Nicholls

4200 SOLAR FLARES AND SURGES OBSERVED AT THE STOCKHOLM OBSERVATORY AND THE SWEDISH ASTROPHYSICAL STATION IN ANACAPRI IN THE YEAR 1959. Y.Öhman.
Stockholms Obs. Ann. (Sweden), Vol. 21, No. 5, 32 pp. (1960).

Observations were carried out at Anacapri on 323 days with a total of 2211 patrol hours. In all, 454 flares and 151 surges were recorded with the 0.7 A H$\alpha$ monochromator. At the Stockholm Observatory (Saltsjöbaden), observations were carried out with the 0.5 A H$\alpha$ monochromator on 169 days with a total of 315 patrol hours. In all, 125 flares were recorded.

4201 SPICULES AND THEIR CONTRIBUTION TO THE FORMATION OF THE SOLAR CHROMOSPHERE. C.J.Macris.
Scientia (Italy), Vol. 95, No. 10, 315-21 (Oct., 1960). In French.

A detailed description of the physical characteristics of solar spicules in relation to their immediate environment — the chromosphere. Recent theoretical and observational work is reviewed with detailed references to (1) variation of the electronic temperature of spicules as a function of chromospheric height, (2) Doppler effects in the spectra of spicules, (3) duration velocity, and dimensions of spicules seen in projection on the solar disk. D.R.Barber

4202 DISCUSSION ON LONGITUDE DIFFERENCES OF CATALOGUES IN VIEW OF DETERMINING EPHEMERIS TIME. S.Aoki.
Astron. J. (USA), Vol. 66, No. 1, 1-4 (Feb., 1961).

The systematic differences among star catalogues are rediscussed in view of determining the correction to be applied to UT in order to give ET if the Improved Lunar Ephemeris (or the moon's ephemeris in the Astronomical Ephemeris for 1960 on) is used. Discussions concerning the above circumstance in the prediction and the reduction of solar eclipses are given. It is noted that the conventional $\Delta T$ ($\Delta T_0$) is preferable for use in the prediction of solar eclipses. A method of determining ET from the reduction of solar eclipses is discussed.

4203 OBSERVATIONS AND TIMES OF MINIMA FOR THREE W URSAE MAJORIS SYSTEMS. B.B.Bookmyer.
Astron. J. (USA), Vol. 66, No. 1, 24-6 (Feb., 1961).

Times of minimum light determined from photoelectric observations are given for AK Herculis, W Ursae Majoris and AM Leonis.

New light elements have been derived for AM Leonis. Earlier discussions of AK Herculis have been on the basis of partial eclipses. The present observations, however, indicate an interval of constant light at the bottom of primary minimum of approximately 35 min duration.

4204 THE LIGHT VARIATION AND ORBITAL ELEMENTS OF AK HERCULIS. L.Binnendijk.
Astron. J. (USA), Vol. 66, No. 1, 27-35 (Feb., 1961).

Photoelectric observations are presented of 520 yellow and 518 blue magnitudes of AK Herculis made during one night in 1959 and ten nights in 1960. The minima show constant light during an interval of 35 min. The orbital elements were derived for complete eclipses; the primary minimum is caused by an annular eclipse.

4205 TIMES OF MINIMUM LIGHT FOR SEVERAL ECLIPSING BINARIES. R.H.Koch.
Astron. J. (USA), Vol. 66, No. 1, 35 (Feb., 1961).

Times of minima were determined from film-strip exposures for 14 eclipsing binaries, leading to three improved periods.

THERMODYNAMIC FUNCTIONS OF ATOMS IN THE INTERIOR OF WHITE SWARF STARS. See Abstr. 3501

4206 SOURCE FUNCTION IN A NON-EQUILIBRIUM ATMOSPHERE. VI. THE FREQUENCY DEPENDENCE OF THE SOURCE FUNCTION FOR RESONANCE LINES.
J.T.Jefferies and O.R.White.
Astrophys. J. (USA), Vol. 132, No. 3, 767-74 (Nov., 1960).

For Pt V, see Abstr. 12249 of 1960. The frequency dependence of the line source function is investigated for the case of pure coherent scattering in the reference frame of the atom. It is shown that the thermal redistribution due to Doppler effect gives a form of scattering similar to complete redistribution in the line core and coherency in the wings. Using a modified form for this redistribution and allowing for some residual non-coherency due to collisions in the frame of the atom, an algebraic solution of the transfer equation is obtained, and emergent line profiles are computed, for an isothermal atmosphere. It is shown that the line shape in the transition region from line core to wing is strongly influenced by the proportion of this residual non-coherency. It is finally suggested that, until the strength of collisional perturbations is better understood from theoretical or laboratory studies, theoretical work on line spectra should adopt complete redistribution in scattering.

4207 SOURCE FUNCTION IN A NON-EQUILIBRIUM ATMOSPHERE. VII. THE INTERLOCKING PROBLEM.
J.T.Jefferies.
Astrophys. J. (USA), Vol. 132, No. 3, 775-89 (Nov., 1960).

A general solution to the equations of statistical equilibrium is presented and applied to the problem of determining the influence of interlocking on the depth variation of line source functions. Approximate uncoupled transfer equations are derived for a simple three-level atom, and their quality is tested against exact solutions. A discussion is given (exemplified by hydrogen) of the influence of coupling for models consisting of larger numbers of levels. The general form of the depth variation in the H and K lines of Ca II is shown to be little different from that derived in earlier papers of this series where interlocking was neglected. It is shown, however, that the strong coupling results in a common value, at a given depth of the H and K line source functions.

THE 21 cm LINE OF HYDROGEN AND THE SPIRAL STRUCTURE OF THE MILKY WAY SYSTEM. See Abstr. 4218

4208 ASTROMETRIC INVESTIGATIONS OF GALACTIC CLUSTERS. I. NGC 129. A.P.Lenham and O.G.Franz.
Astron. J. (USA), Vol. 66, No. 1, 16-23 (Feb., 1961).

From two pairs of plates taken with the 40 in. refractor of the Yerkes Observatory with an epoch difference of 42 yr, the relative proper motions of 70 stars in the region of NGC 129 have been determined. The total number of cluster members brighter than V = 12.4 was found to be about 40 stars within 20 min of arc from the apparent cluster centre. On the basis of its proper motion it is shown that the Cepheid DL Cas has a very high probability of being a cluster member.

4209 OPTICAL DETECTION OF IONIZED HYDROGEN IN THE DIRECTION OF THE GALACTIC CENTRE.
G.Courtès and P.Cruvellier.
C.R. Acad. Sci. (France), Vol. 251, No. 22, 2470-2 (Nov. 28, 1960). In French.

Complex $H_\alpha$ emission has been detected in directions near the galactic centre. The radial velocity of one of the components of this emission (−185 km/sec) is close to the velocities observed in the 21 cm radiation near the centre of the Galaxy and strongly suggests that the $H_\alpha$ nebulosities may also be associated with these central regions. C.Hazard

4210 ON THE PERIODS OF LONG-PERIOD VARIABLES IN GLOBULAR CLUSTERS.
R.B.Stothers and M.Schwarzschild.
Astrophys. J.(USA), Vol. 133, No. 1, 343-6 (Jan.,1961).

Numerical solutions are obtained for the fundamental mode and the first two overtones of radial adiabatic pulsations of a model red giant. The model consists of a helium core surrounded by a hydrogen-rich envelope, the convective part of which contains over half the mass and extends for 98% of the radius. The mass of the model is 1.3 solar masses. Pulsation amplitudes are found to be appreciable only in the outer portions of the convective region, and it is concluded that a more exact investigation would have to allow for helium ionization. Calculations are found to be in excellent agreement with data for three long period variables, one each in M13, M3 and M5. R.A.Newing

4211 THE ORIGIN OF THE CHEMICAL ELEMENTS.
D.A.Frank-Kamenitskii.
Uspekhi fiz. Nauk (USSR), Vol. 68, No. 3, 529-56 (July, 1959).
In Russian. English translation in: Soviet Physics—Uspekhi (USA), Vol. 2(68). No. 4, 600-19 (July-Aug., 1959).

A detailed review article on the origin and chemical composition of the cosmic matter. The regularities in the abundance of elements curve, the possible synthesis of elements and thermonuclear reactions are treated in detail. The theories of prestellar formation of the elements and the theory of neutron capture are discussed. Heterogeneous stars and the reactions involving helium and the allied by-pass processes are considered together with the formation of the elements by processes of athermal acceleration.
S.J.St-Lorant

# Radioastronomy

4212 RADIO ASTRONOMY.
M.Laffineur.
Amer. J. Phys., Vol. 29, No. 3, 198-206 (March, 1961).

The nature, reception, and measurement of extra-terrestrial radio waves are described, followed by a discussion of the correlation of radio objects with optical objects. Radio emission from hydrogen, the sun, and the planets is disccused. The characteristics and resolving power of radio telescopes are explained. A consideration of the educational aspects of radio astronomy concludes the paper. Two appendixes discuss synchrotron radiation and galactic range finding.

4213 A CURICUS FEATURE OF THE RADIO SKY.
R.Hanbury Brown, R.D.Davies and C.Hazard.
Observatory (GB), Vol. 80, 191-8 (Oct., 1960).

The radio isophotes of the sky show a spur of comparatively intense radiation which emerges from the galactic plane at about $l^{II} = 30^0$. The outline of the spur is sketched from surveys made at 38 Mc/s and 158 Mc/s. Existing theories of the nature of the spur are shown to be unsatisfactory. It is suggested that it is either an irregularity in the spiral structure similar to those observed in external galaxies or more probably the remnant of a supernova explosion. C.Hazard

4214 AN OPERATIONAL RUBY MASER FOR OBSERVATIONS AT 21 CENTIMETERS WITH A 60-FOOT RADIO TELESCOPE. J.V.Jelley and B.F.C.Cooper.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 166-75 (Feb., 1961).

A maser preamplifier designed for radiometry at a wavelength of 21 cm is described. The maser is mounted at the focus of the 60 ft reflector of the Harward College Observatory and is being used principally for observations of hydrogen-line radiation from extra-galactic nebulae. An automatic gain stabilization system for the

aser using a modulated-noise reference signal is described and example of an observation made with this stabilization scheme included. The total input noise temperature of the radiometer is .°K, without the gain stabilization, and 148°K with the stabilization.

4215 THE SENSITIVITY OF A LOW-NOISE RADIOMETER (IN THE QUANTUM REGION).
.V.Karlov and B.M.Chikhachev.
adiotekhnika i Elektronika (USSR), Vol. 4, No. 6, 1047-51 une, 1959). In Russian.

The limiting accuracy of measurement of the internal noise vel of a radiometer when the noise temperature is of the order of agnitude of $\hbar\omega/k$ and the noise power is determined by the quan- m Nyquist formula is investigated. Expressions are obtained for e radiometer sensitivity under these conditions. The optimum ternal noise temperature is found for which the sensitivity is a aximum. The calculation shows that for values of $\hbar\omega/kT > 1.5$ e quantum formula differs appreciably from the classical formu- . The result is of importance in the field of molecular amplifiers erating at liquid-helium temperatures in the centimetre wave und. R.C.Glass

4216 THE SENSITIVITY OF A RADIOTELESCOPE AT LOW INPUT-NOISE LEVELS.
.V.Karlov and B.M.Chikhachev.
adiotekhnika i Elektronika (USSR), Vol. 4, No. 6, 1052-6 (June, 959). In Russian.

The results obtained for a radiometer (see preceding abstract) re applied to the problem of the limiting sensitivity of a radio- lescope in measuring the effective temperature of cosmic radio- ources in the case of low input-noise levels. It is shown that the ensitivity is essentially determined by quantum effects even when he input noise temperature is greater than $\hbar\omega/k$. R.C.Glass

4217 10.7 cm SOLAR NOISE BURST OF NOVEMBER 20, 1960.
A.E.Covington and G.A.Harvey.
hys. Rev. Letters (USA), Vol. 6, No. 2, 51-2 (Jan. 15, 1961).

A strong radio burst of more than average intensity was bserved but was not associated with any prominent flare. It seems robable that the burst was associated with a hidden intense flare cated on the far side of the sun. C.Hazard

RADAR OBSERVATIONS OF METEOR TRAILS. See bstr. 4123

4218 THE 21 cm LINE OF HYDROGEN AND THE SPIRAL STRUCTURE OF THE MILKY WAY SYSTEM. G.Elwert.
rgeb. exakt. Naturwiss. (Germany), Vol. 32, 1-78 (1959). In German.
Review article.

4219 SELF-ABSORPTION IN THE 21 cm RADIATION FROM GALACTIC NEUTRAL HYDROGEN. V.Radhakrishnan.
ubl. Astron. Soc. Pacific (USA), Vol. 72, 296-302 (Aug., 1960).

Self-absorption was observed near to the supernova remnant C443. The observation suggests that it must arise in an extended egion of cool hydrogen whose temperature cannot exceed 60°K. he observed spread in radial velocity of the absorption over the egion and the variation of cloud size with radial velocity component uggest the possibility of some kind of systematic motion within the omplex. No absorption of the continuum radiation from IC443 was bserved, suggesting that it cannot lie behind the cloud.
C.Hazard

HYDROGEN EMISSION NEAR THE CENTRE OF THE GALAXY. ee Abstr. 4209

4220 RADIO CONTINUUM EMISSION BY SPIRAL ARMS.
G.B.Field.
Publ. Astron. Soc. Pacific (USA), Vol. 72, 303-7 (Aug., 1960).

The steps in the radio emission observed along the plane of the Galaxy are shown to be consistent with the radiation arising from ynchrotron radiation by fast electrons gyrating in interstellar ields aligned approximately along the spiral arms. It is shown hat the field cannot be isotropic and must be aligned along the arms ut probably deviates slightly from perfect alignment.
C.Hazard

4221 PRELIMINARY OBSERVATIONS OF THE POLARIZATION OF RADIO SOURCES AT A WAVELENGTH OF 21 cm. J.Barat, J.Lequeux and É.LeRoux.
C.R.Acad. Sci. (France), Vol. 251, No. 22, 2476-8 (Nov. 28, 1960). In French.

Observations were made on six sources, including Virgo A. A comparison of the measurements of Virgo A with the remaining five sources suggests that its radiation is polarized. On the assumption that the polarized radiation is associated with the narrow source related to the "jet" observed optically, the degree of polarization is estimated to be greater than, or equal to, 3% ± 1.5%. C.Hazard

4222 RADIO SOURCE MEASUREMENTS AT 960 Mc/s.
D.E.Harris and J.A.Roberts.
Publ. Astron. Soc. Pacific (USA), Vol. 72, 237-55 (Aug., 1960).

An account of a survey made at 960 Mc/s using a 90 ft paraboloid. The majority of the 106 sources studied were taken from the Third Cambridge Survey (3C) and the general reliability of this survey was confirmed. However, of 69 sources from the 3C catalogue whose positions were measured at 960 Mc/s, only 67% agree within the sum of the errors. The median spectral index is shown to be −0.6 and for 80% of the sources lies between −0.3 and −0.9. A comparison of the radio positions with the optical fields supports the idea that the extra-galactic radio sources tend to be associated with elliptical galaxies, and particularly with double and multiple systems. C.Hazard

4223 THE CORRELATION OF RADIO SOURCE SCINTILLATION IN THE SOUTHERN AND NORTHERN HEMISPHERES. P.M.Brenan.
J. atmos. terrest. Phys. (GB), Vol. 19, No. 3-4, 287-9 (Dec., 1960).

Measurements of the amplitude of scintillations of a Centaurus radio source at Halley Bay, Antarctica during the I.G.Y. are correlated with simultaneous observations on a source in Cassiopeia at Jodrell Bank in England. From 388 pairs of observations the correlation coefficient is +0.37. Though the line of sight through the ionosphere of the Jodrell Bank measurements is 2000 km from the geomagnetic conjugate point of Halley Bay, this correlation is taken to indicate that high latitude scintillations and auroral activity are closely correlated. J.M.Stagg

4224 THE MAGNETIC STORM-TIME VARIATION OF RADIO STAR SCINTILLATIONS AND AURORAL RADIO ECHOES.
C.D.Watkins.
J. atmos. terrest. Phys. (GB), Vol. 19, No. 3-4, 289-92 (Dec., 1960).

The frequency of occurrence of radio echoes from aurora and the mean scintillation rate of a radio source in Cassiopeia as recorded at Jodrell Bank over the period 1955-58 are shown on separate diagrams plotted against the magnetic storm time of their occurrence. The variation of geomagnetic K index for Eskdalemuir with magnetic storm time is also given. There is a broad similarity between the curves for scintillation rate and K index, but none between K index and auroral echoes. J.M.Stagg

# Space Research

4225 SOME REMARKS ON THE MOTION OF A SATELLITE OF AN OBLATE PLANET. B.Barrar.
Astron. J. (USA), Vol. 66, No. 1, 11-15 (Feb., 1961).

There has been considerable work recently in trying to compute analytically with great accuracy the effects of the gravitational field of an oblate planet on the motion of a satellite. Recently, Vinti (Abstr. 3427 of 1960) has given a very accurate answer by treating the problem in oblate spheroidal coordinates. The present paper derives by an entirely different method a result that has essentially the same accuracy as that of Vinti's but is in a simpler form. The form of the answer resembles very closely that given by Garfinkel [Astron. J. (USA), Vol.63, 88 (1958)].

SATELLITE OBSERVATIONS OF SOLAR COSMIC RAYS. See Abstr. 3305

MAGNETIC FIELD OF THE OUTER CORPUSCULAR REGION. See Abstr. 3306

ALTITUDE DEPENDENCE AND TIME VARIATION OF THE RADIATION INTENSITY OBSERVED BY U.S. SATELLITE 1958 α. See Abstr. 3308

FRESNEL ZONE PLATE TELESCOPE FOR SATELLITES. See Abstr. 4448

# PHYSICS

## GENERAL

4226 THE 1961 EXHIBITION OF THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY. G.R.Noakes.
Nature (GB), Vol. 189, 535-6 (Feb. 18, 1961).

An account of a selection of the exhibits at the forty-fifth Annual Exhibition of Scientific Instruments and Apparatus held in London on 16-21 Jan., 1961.

4227 1960 VISITING FOREIGN STAFF PROJECT (V.F.S.P.) TEMPLE UNIVERSITY. E.L.Offenbacher.
Amer. J. Phys., Vol. 29, No. 3, 137-42 (March, 1961).

4228 INTERNATIONAL CONFERENCE ON PHYSICS EDUCATION. F.W.Sears.
Amer. J. Phys., Vol. 29, No. 3, 151-60 (March, 1961).

The papers and discussions at the First International Conference on Physics Education, held in Paris from 28 July to 4 August 1960,are summarized.

4229 ON THE EDUCATION OF PHYSICISTS IN AUSTRIA AND ISRAEL. A.M.Goldfarb.
Amer. J. Phys., Vol. 29, No. 3, 161-7 (March, 1961).

The basic systems are described, each followed by a discussion of the training of a potential physicist or physics teacher in that country.

4230 THE EDUCATION OF PHYSICISTS IN SWEDEN. K.G.Friskopp and A.E.Sandström.
Amer. J. Phys., Vol. 29, No. 3, 168-73 (March, 1961).

A survey is given of the school system and the background expected of students advancing to university studies in mathematics, physics, and chemistry. The degrees offered by Swedish universities are briefly described. The courses in physics at Uppsala University are described as an example of the education of physicists.

4231 NEW DEMONSTRATION APPARATUS. V.I.Erofeev, V.K.Rubtsov and S.I.Usagin.
Uspekhi fiz. Nauk (USSR), Vol. 66, No. 3, 519-21 (Nov., 1958).
In Russian. English translation in: Soviet Physics—Uspekhi (USA), Vol. 1(66), No. 2, 274-5 (Nov.-Dec., 1958).

Describes the construction of a "ripple tank" for illustrating wave phenomena. [The method of obtaining a "stationary pattern" would appear to be an improvement on the more usual arrangements, but the method of obtaining "travelling" waves is not clear]. E.G.Knowles

4232 A DIRECT DETERMINATION OF BOLTZMANN'S CONSTANT FROM CIRCUIT NOISE. L.Storm.
Naturwissenschaften (Germany), Vol. 47, No. 21, 490 (Nov., 1960).
In German.

Precision measurements in the frequency range 2-20 kc/s on 20 to 70 kΩ resistors yielded the value $k = 1.3809 \times 10^{-23}$ J deg$^{-1}$ with an accuracy of ±0.12%. S.Weintroub

4233 VARIOUS TYPES OF EQUATIONS AND PROBLEMS OF TECHNICAL DIMENSIONS. C.Kämmerer.
Österr. Ingen. Z. (Austria), Vol. 3, No. 6, 198-204 (June, 1960). In German.

A thorough and logical discussion of various problems of traditional physical, and the new M.K.S.A., unit systems is presented. The fundamental difference between dimension-equations (independent of proportionality coefficients) and unitary equations is explained with the aid of many examples. Difficulties of applying the same derived unit names (like 1 Newton) to compound dimensions (1 kg m sec$^{-2}$) describing different physical phenomena are pointed out; such phenomena possess dimensions, whereas time, for instance, is a dimension. A particular point made is that in the M.K.S.A. system, the unit of mass should be 9.81 kg, not 1 kg. A.Landman

4234 CRITIQUE OF CRITICAL TABLES. P.W.Bridgman.
Proc. Nat. Acad. Sci. USA, Vol. 46, No. 10, 1394-1400 (Oct., 1960).

Introductory paper at the Gordon Conference on Information Processing for Critical Tables of Scientific Data. The factors influencing the selection of a best value of a universal constant are discussed. Of these, the present status of theory and the opinion of the person making the assessment are emphasized. It is suggested that the difficulties of presenting comprehensive data on the properties of different substances, and of different specimens of the same substance, are hardly overcome at the present time and are likely to become more severe in the future. Two examples cited are the complete specification of equations of state including the effect of thermal fluctuations on the values of critical constants, and the effect of the history on the elastic properties of a specimen. In addition, it is pointed out that the use of formulae for extrapolation cannot be justified unless a discussion of the theoretical basis is given. P.Gr

## GRAVITATION . RELATIVITY

4235 WAVE PROPAGATION IN A CLOSED EXPANDING UNIVERSE. N.Rosen and G.E.Tauber.
Bull. Res. Coun. Israel, Vol. 9F, No. 3, 111-22 (Dec., 1960).

The scalar wave-equation is solved for several models of a closed expanding universe by the method of separation of variables. An approximate solution is obtained in the general case for high frequencies.

4236 PROBLEM OF RAINICH FOR SCALAR FIELDS. A.Peres.
Bull. Res. Coun. Israel, Vol. 9F, No. 3, 129-31 (Dec., 1960).

The conditions that have to be imposed on a symmetric tensor so that it can be considered as the energy–momentum tensor of a scalar field, are determined.

4237 THE THEORY OF DISCRETE SPACE–TIME. V.G.Kadyshevskii.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 70-3 (Jan. 1, 1961).
In Russian.

The constants of non-classical theories (c and h) can be regarded as compensations for the information which disappears on leaving the corresponding classical theories. Conversely, if a constant is universal (analogous to c and h), then its appearance is connected with the disappearance of some exact information contained in the corresponding theory without this constant. The author constructs a discrete 4 - space whose points have discrete coordinates and considers the conditions of appearance of universal constants in such a space. [English translation in: Soviet Physics-Doklady (USA)]. J.K.Skwirzynski

4238 GEOMETRY OF LIGHT PATHS BETWEEN TWO MATERIAL BODIES. E.P.Wigner.
J. math. Phys. (USA), Vol. 2, No. 2, 207-11 (March-April, 1961).

The pattern of light signals, which was proposed before for the measurement of the curvature, is investigated in a two-dimensional manifold of constant curvature (deSitter space). The pattern consists of light signals between two freely moving bodies, each signal being emitted when the signal from the other body arrives. It is shown that the coordinates of the arrivals (or emissions) of the light signals can be obtained from the coordinates of the emission of the first signal by means of projective transformations which are iterates of a single such transformation. The same applies to the proper times at which these signals are received.

4239 THE ENERGY OF NON-STATIONARY GRAVITATIONAL FIELDS. A.Papapetrou and H.G.Schoepf.
C.R. Acad. Sci. (France), Vol. 251, No. 25, 2889-91 (Dec. 19, 1960).
In French.

Alternative forms (Einstein, Møller) for the energy pseudo-tensor, which yield the same result for the total energy of a bounded stationary system, are shown to yield results differing by factor 2 for the total energy of a gravitational wave-packet. F.A.E.Pira

4240 MACH'S PRINCIPLE AND SCALAR THEORIES OF GRAVITATION. P.Rastall.
Canad. J. Phys., Vol. 39, No. 1, 218-19 (Jan., 1961).

In a fully covariant scalar theory of gravitation, assume that the field vanishes when the potential is constant. Such constancy is

served by transformations between relatively accelerated co-inate systems. Hence the acceleration of a body cannot be fully rmined by its gravitational interaction with the rest of the uni-se, which contradicts Mach's principle in the sense employed by author. F.A.E.Pirani

4241 DEFORMATION OF THE ACCOMPANYING SPACE IN THE EINSTEIN THEORY OF GRAVITATION.
..Zel'manov.
l. Akad. Nauk SSSR, Vol. 135, No. 6, 1367-70 (Dec. 21, 1960). In sian.
The passage from homogeneous, isotropic cosmological models n anisotropic nonhomogeneous universe is associated with multi-ity of types of behaviour of space accompanying the mass. In ticular, the accompanying space in an anisotropic model can and in one region and decrease its volume in another. The blem is formulated by first postulating general physical pro-ties of the energy and momentum tensor and then by establishing ulting equations (4 equations for the metric tensor and 6 equa-ns for the energy–momentum tensor). [English translation in: iet Physics–Doklady (USA)]. J.K.Skwirzynski

4242 THE COORDINATE CONDITIONS IN EINSTEIN'S THEORY OF GRAVITATION. II. I.G.Fikhtengol'ts.
eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 809-13 pt., 1960). In Russian.
For Pt I see Abstr. 9191 of 1959. It is proved that the coordinate ditions employed in the work of Einstein, Infeld and Hoffman on uction of the equations of motion of a mass system cannot be ived from the condition of invariance of the Lagrange function of gravitational field with respect to some set of coordinate nsformations. Application of these coordinate conditions to astronomical problem of an isolated mass system is shown to be xpedient. [English translation in: Soviet Physics–JETP (USA), . 12, No. 3, 564-6 (March, 1961)].

4243 LORENTZ INVARIANCE AND THE GRAVITATIONAL FIELD. T.W.B.Kibble.
math. Phys. (USA), Vol. 2, No. 2, 212-21 (March-April, 1961).
An argument leading from the Lorentz invariance of the grangian to the introduction of the gravitational field is presented. iyama's discussion is extended by considering the 10 parameter oup of inhomogeneous Lorentz transformations, involving variation the coordinates as well as the field variables. It is then un-cessary to introduce a priori curvilinear coordinates or a Rieman-an metric, and the new field variables introduced as a consequence the argument include the vierbein components $h_k{}^\mu$ as well as the ocal affine connection" $A^i{}_{j\mu}$. The extended transformations for ich the 10 parameters become arbitrary functions of position may interpreted as general coordinate transformations and rotations the vierbein system. The free Lagrangian for the new fields is own to be a function of two covariant quantities analogous to $F_{\mu\nu}$ r the electromagnetic field, and the simplest possible form is st the usual curvature scalar density expressed in terms of $h_k{}^\mu$ d $A^i{}_{j\mu}$. This Lagrangian is of first order in the derivatives, and the analogue for the vierbein formalism of Palatini's Lagrangian. the absence of matter, it yields the familiar equations $R_{\mu\nu} = 0$ for npty space, but when matter is present there is a difference from e usual theory (first pointed out by Weyl) which arises from the ct that $A^i{}_{j\mu}$ appears in the matter field Lagrangian, so that the uation of motion relating $A^i{}_{j\mu}$ to $h_k{}^\mu$ is changed. In particular, is means that, although the covarient derivative of the metric nishes, the affine connection $\Gamma^\lambda{}_{\mu\nu}$ is nonsymmetric. The theory ay be re-expressed in terms of the Christoffel connection, and in at case additional terms quadratic in the "spin density" $S^k{}_{ij}$ pear in the Lagrangian. These terms are almost certainly too nall to make any experimentally detectable difference to the pre-ctions of the usual metric theory.

4244 THE SINGULARITIES OF COSMOLOGICAL SOLUTIONS OF THE GRAVITATIONAL EQUATIONS. II.
M.Lifshits and I.M.Khalatnikov.
n. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 800-8 (Sept., 60). In Russian.
For Pt I see Abstr. 18914 of 1960. A broad class of cosmo-gical solutions of the gravitational equations is found, which ntains seven arbitrary physically different functions of the spatial ordinates. This number is one less than the number of functions, ich is necessary for the description of an arbitrary initial stribution of matter and gravitational fields in the general case. nglish translation in: Soviet Physics–JETP (USA), Vol. 12, No. 3, 8-63 (March, 1961)].

4245 UPPER LIMIT TO ANISOTROPY OF INERTIAL MASS FROM NUCLEAR RESONANCE. R.W.P.Drever.
Phil. Mag. (GB) (Eighth Ser.), Vol. 5, 409-11 (April, 1960).
It is suggested that very sensitive tests of a possible variation of inertial mass with the direction of acceleration with respect to the centre of the galaxy would be provided by nuclear magnetic and quadrupole resonance techniques. See also Abstr. 10561 of 1960. R.A.Newing

4246 RELATIVITY: BLESSING OR BLINDFOLD? M.Ruderfer.
Proc. Inst. Radio Engrs (USA), Vol. 48, No. 9, 1661-2 (Sept., 1960).
Experimental tests of the special theory have involved measurement of a two-way light signal. It is suggested that modern techniques should make possible the determination of the velocity of a one-way signal; it is claimed that such a determination is necessary to distinguish between relativity and a theory involving ether drift and Lorentz–Fitzgerald contraction. R.A.Newing

4247 CONFORMAL COORDINATES ASSOCIATED WITH UNIFORMLY ACCELERATED MOTION. R.T.Jones.
Amer. J. Phys., Vol. 29, No. 2, 124-5 (Feb., 1961).
The author defines conformal coordinates x', t' for a one-dimensional particle motion by

$$x' + ct' = F(x + ct),$$
$$x' - ct' = G(x - ct),$$

where x' = 0 is the world-line of the particle and

$$\frac{\partial F}{\partial x}\cdot\frac{\partial G}{\partial x} = 1$$

on this world-line. Some analogies with hydrodynamics are mentioned. C.W.Kilmister

4248 FURTHER REMARKS ON THE LOCALIZATION OF THE ENERGY IN THE GENERAL THEORY OF RELATIVITY. C.Møller.
Ann. Phys. (USA), Vol. 12, No. 1, 118-33 (Jan., 1961).
The localizability of the energy in gravitational fields is discussed. It is shown that the expression for the energy density derived in an earlier paper (Abstr. 26 of 1959) does not have all the properties required for a satisfactory description of the energy distribution. An essential correction is made to one of the statements in the aforementioned paper. A careful analysis of the desirable properties of the notions in question is carried through, the conclusion being that none of the expressions derived so far satisfies all the requirements necessary for a satisfactory description of the localization of the energy. It is indicated how the "four-leg" formulation of the gravitational theory might provide a solution of the problem.

4249 WAVE ZONE IN GENERAL RELATIVITY. R.Arnowitt, S.Deser and C.W.Misner.
Phys. Rev. (USA), Vol. 121, No. 5, 1556-66 (March 1, 1961).
It is shown that, in general relativity, a "wave zone" may be defined for systems which are asymptotically flat. In this region, gravitational radiation propagates freely, independent of its interior sources, and obeys the superposition principle. The independent dynamical variables of the full theory which describe the radiation are shown to be coordinate invariant in the wave zone and to satisfy the linearized theory's equations there. Thus, the basic properties of free waves in linear field theories (e.g. electrodynamics) are reproduced for the gravitational case. True waves are also clearly distinguished from so-called "coordinate waves". Reduction to asymptotic form (taking leading powers of 1/r), is not identical to linearization since, for example, the Newtonian-like 1/r part of the metric begins quadratically in the linear theory's variables. The Poynting vector of the full theory, which measures energy flux in the wave zone, is correspondingly shown to be given by the linearized theory's formula. This Poynting vector is also shown to be coordinate-invariant in the wave zone. All the physical quantities may therefore be evaluated in any frame becoming rectangular sufficiently rapidly. A brief discussion of measurements of the canonical variables in the wave zone is given. The relation between the present work and other treatments of gravitational radiation is examined.

# QUANTUM THEORY

*(Applications of quantum theory to elementary particles and nuclei are included under Nuclear Field Theory)*

4250 A NOTE ON FERMI COORDINATES. F.A.E.Pirani.
Proc. Roy. Irish Acad. A, Vol. 61, No. 2, 9-14 (Dec., 1960).

Ó Raifeartaigh's condition (Abstr. 2727 of 1958) for the existence of Fermi coordinates on a subspace $U_M (M > 1)$ of a Riemann space $V_N$ is applied, somewhat modified, to some general relativity space–times $V_4$.

4251 ON CERTAIN IDENTITIES CONNECTED WITH THE EINSTEIN TENSOR. J.L.Synge.
Proc. Roy. Irish Acad. A, Vol. 61, No. 4, 29-36 (Dec., 1960).

In solving the field equations to the second order, the identical vanishing of the covariant divergence of the Einstein tensor implies certain identities. For example if

$$g_{ij} = \delta_{ij} + \epsilon a_{ij} + \epsilon^2 b_{ij},$$

and $$G_{ij} = \epsilon L_{ij}(a) + \epsilon^2 [L_{ij}(b) + Q_{ij}(a)] + O(\epsilon^3),$$

then $L_{ij},_j = 0$, and if $L_{ij}(a) = 0$ everywhere in a region, then $Q_{ij},_j(a) = O(\epsilon^3)$. These facts are generalized and strengthened by considering the metric

$$g_{ij} = \delta_{ij} + \lambda_\alpha g^\alpha_{ij}.$$

C.W.Kilmister

4252 STATIC ELECTROMAGNETIC FIELDS IN GENERAL RELATIVITY. A.K.Raychaudhuri.
Ann. Phys. (USA), Vol. 11, No. 4, 501-9 (Dec., 1960).

The solutions are presented of the equations of Rainich's "already unified theory" (1925) for the case when the field is static and the diagonalized metric tensor components are functions of one coordinate alone. Although the solutions obtained occur already in the literature, the new approach seems interesting.

4253 ON THE NONEXISTENCE OF A CLASS OF STATIC EINSTEIN SPACES ASYMPTOTIC AT INFINITY TO A SPACE OF CONSTANT CURVATURE. H.A.Buchdahl.
J. math. Phys. (USA), Vol. 1, No. 6, 537-41 (Nov.-Dec., 1960).

It is known that there exist no nontrivial static regular solutions of the Einstein vacuum equations $R_{kl} = 0$ which are asymptotically Galilean at infinity. One may ask correspondingly whether there exist static solutions of the equations $R_{kl} = \lambda g_{kl}$ $(\lambda = 0)$ which are regular at all finite points and asymptotic (in a sense to be defined) to a space of constant curvature at infinity. The answer to this question is shown here to be in the negative. The proof rests upon the possibility of writing a certain quadratic invariant density of the Riemann tensor in the form of an ordinary divergence.

4254 A POINT EXPLOSION IN AN INCOMPRESSIBLE IDEAL LIQUID IN THE GENERAL THEORY OF RELATIVITY. V.A.Skripkin.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 5, 1072-5 (Dec. 11, 1960).
In Russian.

Einstein's gravitational equations are solved for an incompressible liquid in a central field of force. The motion of the liquid is generally wavelike, but under conditions specified in the paper, it transforms suddenly into flow at the speed of light. [English translation in: Soviet Physics–Doklady (USA)]. R.Eisenschitz

4255 THE REPRESENTATION OF THE MATTER FIELD AND ELECTROMAGNETIC FIELD IN A PURELY GEOMETRIC THEORY. M.A.Tonnelat.
C.R.Acad. Sci. (France), Vol. 251, No. 25, 2892-4 (Dec. 19, 1960).
In French.

The Lagrangian for the Einstein–Schrödinger theory is generalized and the resulting equations provide fields which can be identified as those of matter and electromagnetism. The Cauchy problem then admits 4 supplementary quantities as well as the usual Cauchy variables. C.W.Kilmister

LUMINOSITY DISTANCE AND DOPPLER SHIFT IN RELATIVISTIC COSMOLOGY. See Abstr. 4187

4256 A SOLUTION OF THE COMBINED GRAVITATIONAL AND MESIC FIELD EQUATIONS IN GENERAL RELATIVITY. R.L.Brahmachary.
Progr. theor. Phys. (Japan), Vol. 23, No. 4, 749-50 (April, 1960).

DEMONSTRATION OF QUANTUM MECHANICS IN THE LARGE See Abstr. 3232

4257 THE SPECIAL CANONICAL GROUP. J.Schwinger.
Proc. Nat. Acad. Sci. USA, Vol. 46, No. 10, 1401-15 (Oct., 1960).

The properties of the complementary pair of operators q, p with continuous spectra are obtained as a limit of the operator group considered previously (Abstr. 14511 of 1960). W.A.Hepner

4258 LOWER BOUNDS AND ISOPERIMETRIC INEQUALITIES FOR EIGENVALUES OF THE SCHRÖDINGER EQUATION. J.B.Keller.
J. math. Phys. (USA), Vol. 2, No. 2, 262-5 (March-April, 1961).

The potential which minimizes the lowest eigenvalue of the one-dimensional Schrödinger equation is determined among all potentials V for which the integral of $V^n$ has the prescribed value k. For each value of n and k this potential is found to be a special case of the Epstein–Eckart potentials which were originally introduced because the Schrödinger equation for them could be solved explicitly. The minimum eigenvalue is determined and it provides a lower bound on the lowest eigenvalue of any potential for which $\int V^n dx = k$. The expression of this fact as an inequality yields an isoperimetric inequality. For an arbitrary potential, each value of n provides one lower bound on the lowest eigenvalue, the largest of which is the best. This best bound is determined for the square well, the exponential, and the inverse power potentials. In the case of the square well, it is compared with the exact value. In the limiting case n = 1 the result obtained here reduces to that previously obtained by Spruch, who showed that the delta function has the minimum lowest eigenvalue among all potentials of given "area".

4259 REARRANGED AND TWO-PARAMETER EIGENVALUE PROBLEMS, WHICH CAN BE SOLVED WITH THE HELP OF THE POLYNOMIAL METHOD. A.Rubinowicz.
Acta phys. Polon. (Poland), Vol. 19, No. 5, 533-58 (1960).
In German.

By introducing a parameter into the coefficients q, $\rho$ of the eigenvalue problem

$$\frac{d}{dx} p(x) \frac{df}{dx} - [q(x) - \lambda\rho(x)]f = 0,$$

a rearranged eigenvalue problem can be obtained, which has the same eigenfunctions. Eigenvalue problems which can be solved by the polynomial method can be made to yield not only linear but also quadratic rearranged eigenvalue problems. The linear forms immediately give new orthogonality relations. When a given eigenvalue problem can be written in a rearranged form which is linear, then its eigenfunctions are also solutions of a two-parameter eigenvalue problem. It is possible to select infinite or finite sets of the solutions of such equations which satisfy further orthogonality relations. E.J.Squires

4260 INTEGRAL REPRESENTATION FOR THE NON-RELATIVISTIC COULOMB GREEN'S FUNCTION. E.H.Wichmann and Ching-Hung Woo.
J. math. Phys. (USA), Vol. 2, No. 2, 178-80 (March-April, 1961).

Although the radial Green's function for the Schrödinger equation in a Coulomb field can be obtained in the usual way in terms of the two linearly independent solutions to the radial equation for a particular angular momentum state, the sum over angular momentum state does not seem to have been carried out. In this note this sum is carried out and a "closed form" obtained in the form of a double integral. The result is believed to be useful for perturbation calculations where the "intermediate states" involve many angular momentum states.

4261 AN EXACT DERIVATION OF ORTHOGONAL TWO-ELECTRON ORBITALS. E.Kapuy.
Acta phys. Hungar., Vol. 12, No. 2, 185-7 (1960).

An integro-differential equation analogous to the Hartree–Fock equation is given for these orbitals. In practice, it may be suffi-

nt for them to be nearly orthogonal for good results to be ained; in fact, abandonment of the requirement of orthogonality near-neighbour orbitals is a distinct practical advantage.
J.Hawgood

4262 SPIN IN CLASSICAL AND QUANTUM THEORY. H.C.Corben.
ys. Rev. (USA), Vol. 121, No. 6, 1833-9 (March 15, 1961).
The classical equations of motion of a charged point-particle th intrinsic spin under the influence of an external electromagtic field are restated and compared with the Heisenberg equations motion derived from the Dirac theory. The partition of angular omentum between particle and field in the classical theory is conasted to the Dirac theory of electron spin. The analogy between e Dirac equation and the theory of parametric amplification is inted out. A free spinning point-particle moving according to the ws of classical relativistic point-particle mechanics may move ong a helix. The sum of the intrinsic spin $\vec{\sigma}$ and the angular omentum of the helical motion in this classical analogue of zitterwegung is an effective spin vector $\vec{S}$ which is a constant of the otion. Because of this internal motion, the effective mass M of e particle differs from the mass m which is ascribed to it in the uations of motion. Solutions are found in which $\vec{S}$ is parallel or tiparallel to the momentum, and the sign of M is determined by e helicity. When placed in a uniform electromagnetic field, the rticle behaves as if it had a rest mass M and a magnetic moment /Mc, in addition to any explicit magnetic moment that may be asibed to it.

4263 GROUND STATE OF A SYSTEM CONSISTING OF TWO OPPOSITELY CHARGED PARTICLES IN A COULOMB ELD. M.Inokuti, K.Katsuura and H.Mimura.
ogr. theor. Phys. (Japan), Vol. 23, No. 1, 186-7 (Jan., 1960).
Variational calculations, using a trial function involving the ter-particle distance as well as the distances of the particles from e force centre, show that a bound state is not formed unless the ass-ratio of the particles is greater than 7.8. For example a ositron will not form a bound state with an H atom, but an exciton InSb may be expected to form a bound state at a positively charged perfection. J.Hawgood

4264 THE PHASE SHIFT FORMULA IN THE IMPROVED WKB METHOD. H.Moriguchi.
rogr. theor. Phys. (Japan), Vol. 23, No. 4, 750-2 (April, 1960).
Describes an iteration method for calculating the phase shifts the radial Schrödinger equation, based on that described in Abstr. of 1961. J.Hawgood

4265 BOUNDS ON SCATTERING PHASE SHIFTS FOR COMPOUND SYSTEMS. L.Rosenberg and L.Spruch.
hys. Rev. (USA), Vol. 121, No. 6, 1720-6 (March 15, 1961).
An extension of recently developed methods determines a igorous upper bound on $(-k \cot \eta_l)^{-1}$, where $\eta_l$ is the phase shift, for ne general one-channel scattering process. The method, unfortuately, requires truncation of the various potentials, but it should enerally be possible, in practice, so to truncate the potentials that he difference between the phase shifts of the original problem nd of the problem for which a bound is obtained is insignificant. n the course of the development it is necessary to introduce, for ompound system scattering, an absolute definition of the phase hift, not simply a definition modulo $\pi$. The definition chosen is o take the projection of the full scattering wave function on the round-state wave function of the scattering system, and to treat he resultant one coordinate wave function as if it were the scatterng wave function for a particle on a centre of force. Though rrelevant with regard to the determination of a bound on $\cot \eta_l$, it s interesting that at least for some simple cases this definition utomatically increases the phase shift by at least $\pi$ whenever the auli principle introduces a spatial node into the scattering wavenction. The triplet scattering of electrons by hydrogen atoms rovides an example.

# STATISTICAL MECHANICS TRANSFER PROCESSES

4266 FREQUENCY FACTORS IN THE THERMALLY ACTIVATED PROCESS.
R.Landauer and J.A.Swanson.
Phys. Rev. (USA), Vol. 121, No. 6, 1668-74 (March 15, 1961).
Discussions of the rate, $\nu e^{-U/kT}$, for thermally activated processes, are usually based on the phase-space distribution function for thermal equilibrium. Kramers (1940) has gone beyond this and for the particle in a bistable one-dimensional well has treated the relaxation to equilibrium as a Brownian motion problem in which the one-dimensional motion is coupled to a reservoir through a viscosity. Kramers' arguments are readily extendable to many dimensions. In the overdamped case the reaction rate is reduced below the value derived from thermal equilibrium theory by the factor $\omega_s/\eta$, where $\omega_s$ is the angular frequency associated with the direction of steepest descent at the saddle point and $\eta$ the viscosity. In the underdamped case equilibrium theory is valid for many-dimensional systems, except for extreme degrees of underdamping.

4267 DYNAMICS OF NONLINEAR STOCHASTIC SYSTEMS. R.H.Kraichnan.
J. math. Phys. (USA), Vol. 2, No. 1, 124-48 (Jan.-Feb., 1961).
A method for treating nonlinear stochastic systems is described which it is hoped will be useful in both the quantum-mechanical many-body problem and the theory of turbulence. In this method the true problem is replaced by models that lead to closed equations for correlation functions and averaged Green's functions. The model solutions are exact descriptions of possible dynamical systems, and, as a result, they display certain consistency properties. For example, spectral components of Green's funtions which must be positive-definite in the true problem automatically are so for the models. The models involve a new stochastic element: random couplings are introduced among an infinite collection of similar systems, the true problem corresponding to the limit where these couplings vanish. The method is first applied to a linear oscillator with random frequency parameter. The mean impulse-response function of the oscillator is obtained explicity for two successive models. The results suggest the existence of a sequence of model solutions which converges rapidly to the exact solution of the true problem. Applications then are made of the Schrödinger equation of a particle in a random potential and to Burger's analogue for turbulence dynamics. For both problems, closed model equations are obtained which determine the average Green's function, the amplitude of the mean field, and the covariance of the fluctuating field. The model solutions can be expressed as sums of infinite classes of terms from the formal perturbation expansions of the solutions to the true problems. It is suggested that correspondence to stochastic models may be a useful criterion to help judge the validity of partial summations of perturbations series.

4268 SOLUTION OF THE EQUATIONS OF STATISTICAL MECHANICS. R.M.Lewis.
J. math. Phys. (USA), Vol. 2, No. 2, 222-31 (March-April, 1961).
The solution of the initial value problem for Bogolyubov's functional differential equation of nonequilibrium statistical mechanics is obtained. This solution is then expanded in an infinite power series in the density which has the advantage that the calculation of the leading terms requires the solution of s-body problems only for small values of s. A derivation of the equilibrium equations by reduction from the nonequilibrium equation is included. These results are applied to obtain a simple derivation of the Boltzmann equation.

4269 THE EQUILIBRIUM DISTRIBUTION OF N ATOMS ON N SITES (OR IN N CELLS). E.A.Guggenheim.
Proc. Phys. Soc. (GB), Vol. 76, Pt 4, 580-1 (Oct. 1960).
The grand partition function, free energy, etc, are given for the multiple-occupation distribution. J.Hawgood

4270 DENSITY EXPANSIONS OF CORRELATION FUNCTIONS FOR EQUILIBRIUM SYSTEMS. H.L.Friedman.
J. chem. Phys. (USA), Vol. 34, No. 1, 73-8 (Jan., 1961).
A method of deriving density expansions of correlation functions from density expansions of the excess free energy is based on certain thermodynamic relations between derivatives of the grand

partition function and derivatives of the excess free energy. The method also depends on using the most general expansion of the interaction energy into components; it is not assumed that this energy is limited to pairwise components. Expansions are obtained for the correlation functions in multicomponent gases and for the correlation functions for solute species in solutions. The method is also applicable to ionic solutions. A mathematical difficulty limits the systems for which these equations are proved to those in which there is a certain flexibility in treating the model.

4271 ON THE STATISTICAL THEORY OF NON-LINEAR FIELDS. Ya.P.Terletskii.

Dokl. Akad. Nauk (SSSR), Vol. 133, No. 3, 568-71 (July 21, 1960). In Russian.

For abstract see Abstr. 1705 of 1961. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 812-15 (Jan.-Feb., 1961)].

4272 ENTROPY OF LOCALIZATION AND EXTENSION IN A QUANTUM MECHANICAL SYSTEM.

D.A.Bochvar, I.V.Stankevich and A.L.Chistyakhov.

Dokl. Akad. Nauk SSSR, Vol. 135, No. 5, 1095-6 (Dec. 11, 1960). In Russian.

If $h = -\int_D \rho \log \rho \, d\tau$, (where $\rho$ is the density of a uniform distribution given in a finite domain D) is the entropy of localization, then the h-extension is defined to be $e^h$ units of volume. Three examples are given. [English translation in: Soviet Physics—Doklady (USA)]. G.A.Chisnall

4273 CLUSTER INTEGRAL THEORY OF DISTRIBUTION FUNCTIONS OF SPATIALLY NONUNIFORM SYSTEMS. R.V.Hanks.

Phys. of Fluids (USA), Vol. 4, No. 3, 292-99 (March, 1961).

The theory of the pair distribution function of quantum and classical systems developed by Fujita et al. [Bull. Acad. Roy. Belgique Cl. Sci., Vol. 44, No. 11, 1018 (1958)] is extended to apply to spatially nonuniform systems. Cluster integral expansions of the singlet and pair distribution functions are developed for both one- and two-component systems, and are used to derive general expressions for these functions of noninteracting Fermi—Dirac and Bose—Einstein gases. The pair distribution function of a low-density, high-temperature plasma in a homogeneous external magnetic field is also considered and it is shown, under certain assumptions, that the Debye screening length is unaffected by the field.

4274 THE GREEN'S FUNCTION OF THE LIOUVILLE EQUATION. F.C.Andrews.

Bull. Acad. Roy. Belgique Cl. Sci., Vol. 46, No. 6, 475-85 (1960).

The function is developed by an inverse operator technique; several special cases of the general function are studied. Using the same technique, the n-body interaction is investigated to determine the validity of replacing $f_n$, the distribution function (D.F.) of the n bodies during or after their interaction, by the asymptotic form of the D.F. for the n particles calculated at positions and momenta the particles would have had before their interaction. This replacement is found to be strictly valid.

4275 CORRECTION TO THE DEBYE—HÜCKEL THEORY. J.G.Trulio and S.G.Brush.

Phys. Rev. (USA), Vol. 121, No. 4, 940 (Feb. 15, 1961).

The correction to the equation of state of a classical electron gas is calculated by the method of Abe (Abstr. 18991 of 1960). The results are compared with those obtained by a different method by Bowers and Salpeter (Abstr. 14535 of 1960).

4276 QUANTUM-CORRECTED STATISTICAL METHOD FOR MANY-PARTICLE SYSTEMS: THE DENSITY MATRIX. L.C.R.Alfred.

Phys. Rev. (USA), Vol. 121, No. 5, 1275-82 (March 1, 1961).

Quantum corrections are obtained for the single-particle density matrix in a semiclassical ensemble where the distribution is unrestricted. A form for the density matrix containing explicitly a function of the wave-mechanical Hamiltonian operator is devised; a formalism is then developed to decompose this operator function into effectively classical and nonclassical parts. The classical part corresponds to the semiclassical density matrix and the quantum corrections are obtained from the nonclassical terms. The quantum-corrected density matrix for a spherically symmetrical and a one-dimensional system are evaluated. The densities for a linear harmonic oscillator and a Coulomb potential for a Fermi—Dirac distribution are also examined in some detail.

4277 INTEGRAL EQUATIONS FOR PAIR DISTRIBUTION FUNCTION. T.Morita and K.Hiroike.

Progr. theor. Phys. (Japan), Vol. 23, No. 2, 385-7 (Feb., 1960).

Various authors have shown independently that the so-called "hypernetted chain approximation" for the virial expansion of the distribution function is equivalent to a coupled pair of integral equations. The hypernetted chain approximation takes account of all graphs of "series-parallel" type. The approximation can be improved by including further types of graph, and it is stated that "we can in principle reach the exact pair distribution function". H.N.V.Temperl

4278 BOSE EINSTEIN CONDENSATION OF CORRELATED PAIRS. T.Matsubara and J.M.Blatt.

Progr. theor. Phys. (Japan), Vol. 23, No. 3, 451-74 (March, 1960).

In the pair-correlation, or quasichemical equilibrium, approximation to statistical mechanics, there appears the possibility of a condensation phenomenon closely analogous to a Bose—Einstein condensation of correlated pairs of particles. However, the expansion used in earlier work to establish this phenomenon fails to yield an adequate approximation at and below the condensation point. Here an alternative development is given, first formally for an arbitrary number of quantum states of the pair, and then carried out in detail for the case of only one, or only two, quantum states of the pair. It is shown that, in spite of the Fermi—Dirac statistics of the particles making up the pairs, it is nevertheless possible to accommodate an arbitrarily large number of particles within a single pair state. Furthermore, if two quantum states of the pair are possible, and conditions are such that either the pair state would be occupied by a macroscopic number of particles if it alone were present, then the Pauli exclusion principle works in such a way that the lower one of the two pair states is occupied by a macroscopic number of particles, whereas the occupation number of the upper pair state remains independent of the volume. This result is not restricted to pairs whose mean separation exceeds their internal size, but applies also to pairs which completely overlap each other. The result is therefore of significance in the theory of superconductivity where the electron pairs have an internal size of the order of the Pippard coherence length, which is much larger than the mean separation of their centres of gravity.

4279 A SUBJECTIVE GENERALISATION OF STATISTICAL MECHANICS. K.Kawasaki.

Progr. theor. Phys. (Japan), Vol. 23, No. 4, 754-5 (April, 1960).

Gives an introductory account of an averaging process applicable when the average value of a macroscopic variable is known at a number of different instants in time. A fuller account will appear elsewhere and (see following abstract) it is stated that an entropy concept can be formulated even in the absence of equilibrium. H.N.V.Temperle

4280 AN ENTROPY CONCEPT IN STATISTICAL MECHANIC K.Kawasaki.

Progr. theor. Phys. (Japan), Vol. 23, No. 4, 755-7 (April, 1960).

See preceding abstract. If an assembly is observed at several different times, it is claimed that the "variation of entropy" with time can be consistently compared with the idea of "the total information available after each observation". H.N.V.Temperle

4281 MOTION OF AN IMPURITY PARTICLE IN A BOSON SUPERFLUID. M.Girardeau.

Phys. of Fluids (USA), Vol. 4, No. 3, 279-91 (March, 1961).

The problem of the low-lying spectrum of a system of many bosons and one impurity particle interacting by repulsive, central, two-body forces is treated by first eliminating the dynamical variables of the impurity in terms of an added effective boson—boson interaction, and then treating the boson system by an extension of Bogolyubov's method. In this way various physical properties of the clothed impurity particle, including its dispersion relation and effective mass, are obtained; singularities associated with the onset of acoustical wave drag as the impurity speed reaches the speed of sound in the boson medium are predicted. The parameters measuring the smallness of the corrections to the present results are shown to be the dimensionless boson—boson interaction, the dimensionless boson—impurity interaction, and the boson—impurity mass ratio. The treatment is then adapted to the case of hard spheres a

density by employing the Huang–Yang–Lee pseudopotential thod; the results are valid if the dimensionless boson density and boson–impurity mass ratio are small. A few remarks are made cerning the connection of the models treated with experimentally essible results.

ONE-PARTICLE MOTIONS IN MANY-PARTICLE SYSTEMS. Abstr. 3430

INCLUSION OF HOLE MOTIONS IN BRUECKNER THEORY. Abstr. 3144

4282 ANALYTIC PROPERTIES OF SINGLE-PARTICLE PROPAGATORS FOR MANY-FERMION SYSTEMS. J.Luttinger.
ys. Rev. (USA), Vol. 121, No. 4, 942-9 (Feb. 15, 1961).
Certain general properties of single-particle propagators for a stem of interacting fermions are derived. In addition, the proper- s of the proper self-energy part $G_k(\xi)$ which were used in previous k (Abstr. 10607 of 1960) on the ground-state energy and on the rmi surface are established. In particular, the fact that to all lers of perturbation theory in the interaction, $\mathrm{Im}G_k(x\text{-}i0^+)$ behaves e $C_k(x-\mu)^2$ ($C_k > 0$) for x very near $\mu$, is proved.

4283 PERTURBATION THEORY FOR AN INFINITE MEDIUM OF FERMIONS. II. A.Klein.
ys. Rev. (USA), Vol. 121, No. 4, 950-6 (Feb. 15. 1961).
For Pt I, see Abstr. 5371 of 1959. New forms of the linked ister expansion for the ground-state energy of a normal spherical stem are given in terms of the exact single-particle propagator d of the associated self-energy operator. These forms are shown be stationary with respect to variations of the latter quantities. new concise proof of the Hugenholtz–Van Hove theorem on single- rticle energies is then possible. The variational principle also plains the insensitivity of recent binding energy calculations to e choice of single-particle energies. It is shown how all results y be extended to systems with anisotropic features.

4284 PERTURBATION THEORY FOR AN INFINITE MEDIUM OF FERMIONS. III. DERIVATION OF THE LANDAU EORY OF FERMI LIQUIDS. A.Klein.
ys. Rev. (USA), Vol. 121, No. 4, 957-61 (Feb. 15, 1961).
The methods employed in Pt I and II for the ground-state energy a normal fermion system are extended to finite temperatures. e basic assumption is that the density matrix of the actual system thermodynamic equilibrium can be derived by adiabatic trans- rmation from the density matrix of a system of noninteracting rticles at the same temperature, volume, and chemical potential. wever, the spectrum of the noninteracting system must be depend- t on the intensive parameters. The self-consistency of the scheme exhibited by demonstrating that the effect potential characterizing is system can be related to the self-energy operator of the actual stem. Two equivalent versions of the theory are derived. In one these the basic equations are precisely those of the Landau theory Fermi liquids with the difference, however, that all quantities are ven explicitly from first principles.

4285 INVARIANT IMBEDDING AND THE REDUCTION OF TWO-POINT BOUNDARY VALUE PROBLEMS TO ITIAL VALUE PROBLEMS. R.Bellman, R.Kalaba and G.M.Wing.
oc. Nat. Acad. Sci. USA, Vol. 46, No. 12, 1646-9 (Dec., 1960).
Describes a general method of reducing systems of differential uations subject to two-point boundary conditions to initial value oblems. The original system of equations is mathematically uivalent to a certain classical transport problem which can be rmally solved by the "invariant imbedding" process used in rmer papers (this approach being practically equivalent to the e of a generating function in many variables). The transformation justified by physical arguments. H.N.V.Temperley

APPROXIMATE THECRY OF TRANSPORT IN SIMPLE DENSE LUID MIXTURES. See Abstr. 4329

4286 ON THE EXTREMUM PROPERTY IN THE VARIATION PRINCIPLE IN THE THEORY OF TRANSPORT ROCESSES. H.Nakano.
rogr. theor. Phys. (Japan), Vol. 23, No. 3, 525-7 (March, 1960).
The author's variation principle is a method for determining ave-functions in such a way that the linearized equation of motion for the density matrix is satisfied. According to this principle transport coefficients can be represented as extreme (or stationary) values of a functional having the form of an integral over an expression involving the wave-function which is to be determined. R.Eisenschitz

4287 ON THE EXTREMUM PROBLEM IN THE VARIATION PRINCIPLE IN THE THEORY OF SUSCEPTIBILITY OR RELAXATION PHENOMENA. H.Nakano.
Progr. theor. Phys. (Japan), Vol. 23, No. 3, 527-9 (March, 1960).
See preceding abstract. Formulae for transport coefficients are with minor modifications applicable to (real or complex) magnetic susceptibilities. R.Eisenschitz

4288 ON THE EIGENVALUE PROBLEM ASSOCIATED WITH THE SOLUTION OF THE GENERALIZED DIFFUSION EQUATION. A.Miyake.
Progr. theor. Phys. (Japan), Vol. 23, No. 3, 521-2 (March, 1960).
A proof that, in the eigenvalue solution of the generalized diffusion equation, each term is multiplied by $\exp(-\lambda t)$, where $\lambda$ is non-negative. H.N.V.Temperley

4289 THE MATHEMATICS OF RADIATIVE TRANSFER. I.W.Busbridge.
London: Cambridge University Press, (1960). vii + 143 pp. [Cambridge tracts in mathematics and mathematical physics, No. 50].
The tract, a successor to Hopf's classical tract on the same subject, seeks to provide a unified and mathematically rigorous treatment of some modern methods of importance in the development of exact solutions of the equation of transfer for plane-parallel homogeneous atmospheres and stationary radiation fields. Finite and semi-infinite atmospheres are considered, attention being restricted in the case of finite atmospheres to axially symmetric problems with isotropic scattering. The first part of the book, "Auxiliary Mathematics", develops the theory of H-functions and of integral operators. The main part of the book, "Milne Equations" develops a powerful combination of the Ambartsumyan technique and Neumann solutions, and covers iterative solutions, the Wiener–Hopf solution, solutions of the non-homogeneous equation, X- and Y-functions, finite atmospheres, and anisotropic scattering. Some incompletely solved problems are reviewed in an appendix. Although the book is concerned with the mathematics of transfer problems in astrophysics, the results are of importance in the theory of neutron diffusion, and a bibliography includes references to papers in this field. R.A.Newing

4290 THERMAL NOISE IN DISSIPATIVE MEDIA. H.A.Haus.
J. appl. Phys. (USA), Vol. 32, No. 3, 493-500 (March, 1961).
To account for the spontaneous thermal fluctuations in a general dissipative medium, a current-source term may be introduced into Maxwell's equations. The dyadic correlation function of the source term is evaluated for a uniform medium at uniform temperature in which the driving field E and driven-current density $J_d$ are related by differential equations in time and space variables. In those cases in which a simple tensor relation exists between the Fourier components of E and $J_d$ at a particular frequency, the result is generalized to nonuniform media. A similar generalization is achieved only under some restrictive assumptions for media characterized by differential equations in the space variables. The results obtained may be applied to the computation of thermal noise radiated from a medium at nonuniform temperature, and can serve as an aid toward understanding of noise mechanisms. The source term is also evaluated for a thin plasma from simple physical reasoning and is found to check with the result derived from the general theory.

4291 QUANTUM FORMALISM ADAPTED TO RADIATION IN A COHERENT FIELD. W.H.Wells.
Ann. Phys. (USA), Vol. 12, No. 1, 1-40 (Jan., 1961).
The purpose is to introduce a formalism that simplifies explicit calculations and improves understanding of the topic. The state of the radiation field is described by Wigner's probability density of position and momentum for each harmonic oscillator that represents a mode of the field. For oscillators, Wigner's density varies in time exactly like a classical density; i.e. probability propagates along space–time paths that obey the classical equation of motion. The new formalism exploits this appearance of a classical equation of motion in the quantum-mechanical problem. A method is devised for reducing atomic systems (matter) that interact with the field to impedance and noise, which enter into the equations of motion in the

usual classical way. This description of matter reduced quantum-radiation theory to classical-noise theory of linear networks. As simple examples of the method, impedance and noise are derived for two systems: a general dissipative system, and the molecular beam of an idealized gas maser. The radiation theory is approached as the most obvious application of a more general theory of coupled systems. The general theory is presented first, applying Feynman's nonrelativistic space–time approach to the Wigner density. The mechanics of a system is described by the probability (in Wigner's sense) of each path of the coordinates in space–time. The influence of one system on another is described by the probability of a force function.

# GENERAL MECHANICS

4292 INVESTIGATION OF THE DYNAMIC STABILITY OF PLATES USING AN ELECTRONIC DIGITAL COMPUTER. A.Yu.Birkgan and A.S.Vol'mir.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 5, 1083-5 (Dec. 11, 1960). In Russian.

Square thin plates are considered, supported on their edges and subjected to dynamic loading causing compression in a single direction. The stress changes with time, increasing linearly with a given rate. The mean deformation, normal to the plane of plate is illustrated at different times of stress application. [English translation in: Soviet Physics–Doklady (USA)]. J.K.Skwirzynski

4293 THE INFLUENCE OF ELASTIC DEFORMATION UPON THE MOTION OF A BALL ROLLING BETWEEN TWO SURFACES. K.L.Johnson.
Proc. Instn Mech. Engrs (GB), Vol. 173, No. 34, 795-810 (1959).

When a ball rolls between two surfaces, in general, a tangential contact force and a relative angular velocity of spin are present at each point of contact. Both these actions give rise to tangential frictional tractions transmitted across the contact surface which are shown to result in a velocity of creep of the ball in a direction perpendicular to the nominal rolling path. The magnitude of the creep velocity depends critically upon the magnitudes of the tangential force and the velocity of spin. If these actions are small there is negligible slip between the contacting surfaces and the creep motion is predominantly a function of the elastic properties of the materials. At larger spin velocities slip extends over a greater proportion of the contact area and the creep is influenced by the frictional properties of the surfaces. Creep measurements were made over a wide range of conditions of rolling. The results are reduced to non-dimensional form, in terms of two parameters expressing the effect of tangential forces and spin respectively. The resistance to rolling was measured and is shown to control the axis about which the ball rolls. The detailed mechanism of the rolling process is discussed.

DOMINO RULE. A WAY OF HANDLING RELATIVE VELOCITIES. See Abstr. 4182

# MECHANICAL MEASUREMENTS

4294 SENSITIVE OUTPUT INDICATOR FOR DIFFERENTIAL TRANSFORMER DISPLACEMENT DETERMINATIONS. D.Wobschall.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 71-3 (Jan., 1961).

A transistorized circuit particularly designed as an output indicator for linear variable differential transformers for the measurements of small displacements is discussed. Resolution of the unit is about 0.05 $\mu$; the linearity is about $\frac{1}{4}\%$.

4295 INTERFEROMETRIC INSTRUMENT FOR THE RAPID MEASUREMENT OF SMALL DIAMETERS. D.H.Blackburn.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 137-9 (Feb., 1961).

The test fibre is placed between two optically flat surfaces and, using the fibre as a fulcrum, the upper flat is adjusted until the surfaces are parallel; the absence of interference fringes between the surfaces is used to indicate parallelism. Controlled tilting of the upper flat is obtained by adjusting, with a micrometer screw, a sliding wedge under a lever attached to the upper flat. The fibre diameter is a linear function of wedge position as indicated by micrometer screw setting.

4296 INTERFEROMETRIC TESTING OF THE PLANENESS OF LONG BEDS. K.Kuhne.
"Optics of all Wavelengths" Meeting, Jena, 1958 (See Abstr. 224 of f 1961) p. 362-8. In German.

The testing of beds of some metres in length for precision machinery is described. An interferometric set up is used which employs Fizeau double slits and an autocollimation device. Constructional and operational details are given. As an example the testing of a 4 m long test-bed is illustrated. S.Tolanski

4297 SHAFT POSITION INDICATOR FOR USE WITH JOURNAL BEARINGS. J.J.Hunter and C.J.Hughes.
Brit. J. appl. Phys., Vol. 12, No. 2, 73-80 (Feb., 1961).

A description is given of equipment using transitors and designed for the indication and measurement of the position of the shaft within the bush of a journal bearing system. Shaft movements cause variations in the impedance of inductive transducers, unbalancing the a.c. bridge of which they are part. The bridge output in the form of an amplitude-modulated carrier, is supplied to an a.c. amplifier and then demodulated to recover a voltage proportional to shaft displacement. By monitoring the bearing on two diameters at right angles and supplying the demodulator outputs to the X- and Y-plates of a cathode-ray oscilloscope, a polar plot of shaft movement is possible and the form of vibration can be observed directly. Although designed for use on a bearing o about 1 in. diameter, the equipment is easily adjustable for other bearing sizes and can give useful information with shaft speeds up to 20 000 rev/min. Circuit details are given and discussed and an assessment is made of the accuracies of the various units.

4298 A METHOD OF AUTOMATIC COMPENSATION IN MEASURING LOW GAS PRESSURES. V.I.Bakhtin.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 88-93 (Jan.-Feb.). In Russian.

Experimental prototypes are described of a device for measuring pressures over a wide range and with a great accuracy, independent of the kind of gas. The operation of the instrument is based upon the method of automatic compensation of gas pressures which deform an elastic membrane by means of the ponderomotive forces of a magnetic field. The gas pressure is determined by measuring the electric current flowing in the winding of the actuating mechanis The device is free of the shortcomings inherent in deformation manometers. [English translation in: Instrum. exper. Tech. (USA No. 1, 96-101 (Jan.-Feb., 1958; publ. April, 1959)].

4299 A PRECISION MERCURY MANOMETER. D.N.Astrov and A.S.Borovik-Romanov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 132-4 (Jan.-Feb.). In Russian.

This manometer allows measurements down to 1 mm Hg with an accuracy of ± 0.03 mm.

4300 SENSITIVE DIAPHRAGM TYPE PRESSURE TRANSDUCER. D.R.Lovejoy.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 41-3 (Jan., 1961).

A simple diaphragm-type transducer for small differences in gas pressures is described together with a suitable electronic arrangement for using it as a control element. The sensitivity of the arrangement is limited by ambient temperature effects on the diaphragm. A zero stability of about 0.1 $\mu$ Hg has been achieved and this could probably be improved on by sufficiently good thermostating. An important feature of the diaphragm is that it may be subjected to large unbalanced pressures without damage, although such pressures will produce zero shifts equivalent to a few microns of mercury.

4301 FREQUENCY MEASUREMENT OF STANDARD FREQUENCY TRANSMISSIONS. S.N.Kalra.
Canad. J. Phys., Vol. 39, No. 2, 380 (Feb., 1961).

Measurements were made at Ottawa, Canada, of the frequency drifts of three standard frequency transmissions (M.S.F., G.B R. and W.W.V.B.), using an N.R.C. caesium-beam frequency resonator as reference standard (with an assumed frequency of 9 192 631 770 c/s). Frequency deviations from nominal are quoted in parts per $10^{10}$.

# MECHANICS OF FLUIDS

*(See also Magnetohydrodynamics)*

4302 CAPILLARY VISCOMETERS OF NEGLIGIBLE KINETIC ENERGY EFFECT.
W.A.Caw and R.G.Wylie.
Brit. J. appl. Phys., Vol. 12, No. 3, 94-8 (March, 1961).

By incorporating capillaries with long-flared ends in otherwise conventional U-tube or suspended-level viscometers, it is possible to produce instruments in which no significant kinetic energy effect occurs for the Reynolds numbers generally encountered in viscometry. A detailed experimental study of their behaviour has been made. Using the new viscometers a viscosity scale in absolute units can be established with greater accuracy and greater facility than has hitherto been possible.

4303 VARIATIONAL PRINCIPLES IN THE MECHANICS OF COMPRESSIBLE FLUIDS. B.F.de Veubeke.
Ann. Soc. Sci. Bruxelles I (Belgium), Vol. 74, No. 3, 157-74 (1960).
In French.

Establishes transformations which enable one to pass from a variational principle of Lagrangian type, in which attention is fixed on individual particles in the fluid, to a variational principle of Eulerian type, in which the variations pertain to fixed points in space. The basic step is to take account of the conservation of mass by means of an undetermined multiplier. This quantity is eventually interpreted in terms of Weber's transformation. When vorticity is present, the method leads to an application of Clebsch's transformation. H.N.V.Temperley

4304 THE STATISTICAL BEHAVIOR OF INSTABILITIES IN DISPLACEMENT PROCESSES IN POROUS MEDIA.
A.E.Scheidegger and E.F.Johnson.
Canad. J. Phys., Vol. 39, No. 2, 326-34 (Feb., 1961).

The problem of growth of instabilities (fingers) in displacement processes in porous media is analysed from a statistical viewpoint. The relative area occupied by fingers is represented as a "saturation", and the equations of motion for this "saturation" are derived. It is shown that these equations are analogous to the Buckley–Leverett equations of immiscible displacement, with a fictitious "relative permeability" being introduced. The latter can be calculated and thus the statistical equations of motion of a fingered-out front can be written down explicitly. These equations of motion can then be solved by the well-known method of characteristics. It is shown that the statistical theory does not lead to any stabilization of the fingers.

4305 STABILITY OF A STOKESIAN FLUID IN COUETTE FLOW. W.P.Graebel.
Phys. of Fluids (USA), Vol. 4, No. 3, 362-8 (March, 1961).

The stability of a Stokesian fluid (Reiner–Rivlin fluid) in Couette motion is examined and shown to depend on the Taylor number as well as a further dimensionless parameter which is proportional to the coefficient of cross viscosity The method of Chandrasekhar is used for small values of this parameter. It is found that for fluids with a positive coefficient of cross viscosity, the critical Taylor number can be appreciably smaller than for the corresponding flow of a Newtonian fluid.

4306 FLOW OF A VISCOPLASTIC MEDIUM BETWEEN ROTATING DISKS. A.M.Gutkin.
Dokl. Akad. Nauk SSSR, Vol. 134, No. 5, 1048-50 (Oct. 11, 1960).
In Russian.

The problem of a viscoplastic medium between two rough parallel rotating disks is analysed theoretically, and expression obtained for the flow and the pressure distribution. The results for two particular cases are derived from the general solution: (1) the two disks approach each other with small velocity, and (2) the viscoplastic medium is continuously introduced into the space between the disks. [English translation in: Soviet Physics–Doklady (USA)].
R.F.S.Hearmon

4307 A CONTRIBUTION TO THE THEORY OF ANISOTROPIC TURBULENCE. V.G.Nevzglyadov.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 2, 283-6 (Nov. 11, 1960).
In Russian.

The dynamics of turbulent flow can be formulated in terms of a relationship between two tensors, the turbulent stress and the averaged rate of strain. The simplest possible relation between these tensors involves isotropy of the medium and is of the same form as the strain–stress relationship in isotropic elastic bodies. Greater generality is attained by replacing the stress by the sum of the stress tensor and a supplementary tensor, thus abandoning the assumption of isotropy. There is no unique deduction of the form of the supplementary tensor. A number of possible assumptions are discussed. The choice between them is to be made in such a way that experimental results are fitted. [English translation in: Soviet Physics–Doklady (USA)]. R.Eisenschitz

4308 A CONTRIBUTION TO THE STATISTICAL DYNAMICS OF TURBULENT [FLOW OF] INCOMPRESSIBLE LIQUIDS. B.I.Davydov.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 47-50 (Jan. 1, 1961).
In Russian.

The conventional and cumbersome specification of turbulent flow in terms of two-point expectations of hydrodynamical quantities is to be replaced by expectations of hydrodynamical quantities at a single point. Accordingly a self-contained statistical specification of uniform turbulence is attempted in terms of the expectations of the following quantities: single components of velocity, their two-fold and three-fold products, the square of the rate-of-shear components and the product of that square and a single component of velocity, all of which are related to single points only. A set of equations is given by which these quantities are determined. [English translation in: Soviet Physics–Doklady (USA)].
R.Eisenschitz

4309 ON THE MECHANISM OF TURBULENT TRANSITION. R.Betchov.
Phys. of Fluids (USA), Vol. 3, No. 6, 1026-7 (Nov.-Dec., 1960).

A simple model of secondary instability which may be related to the process of turbulent transition is discussed. It is based on the properties of Tollmien–Schlicting boundary layer oscillations and on the observations of Kelbanoff and Tidstrom [NASA Tech. Note D-195 (1959)]. S.Weintroub

STOCHASTIC APPROACH TO TURBULENCE. See Abstr. 4267

4310 EXPERIMENTAL INVESTIGATION OF TURBULENT JETS OF AXIAL SYMMETRY. E.I.Polyakov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1238-44 (Oct., 1960).
In Russian.

Extensive measurements were made to determine the velocity profile of jets at various points. Results are discussed in detail. It was found that the distribution (as distinct from the mean) of velocities at the nozzle has only a limited influence on the propagation of the jet. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 10, 1173-9 (April, 1961)]. R.Eisenschitz

4311 EXPANSION AND CONTRACTION OF CAPILLARY JETS OF NEWTONIAN LIQUIDS. S.Middleman and J.Gavis.
Phys. of Fluids (USA), Vol. 4, No. 3, 355-9 (March, 1961).

Laminar jets of Newtonian liquids are found to contract or to expand upon ejection from a capillary nozzle depending upon conditions of ejection and fluid properties. The ratio of final jet diameter to nozzle diameter is a function of Reynolds number Re, and a weak function of Weber number. At $Re < 6$ expansion becomes independent of Re at a diameter ratio of 1.06, if the Weber number dependence is removed At $Re > 150$ contraction becomes independent of Reynolds number at a diameter ratio of 0.87. These results are explained by means of the momentum and energy equations for the motion. The terms in the equations leading to expansion are comparable to relaxing normal stress terms. The existence of relaxing normal stresses in Newtonian liquid jets leads to some questions concerning the origin of normal stresses which are thought to be responsible for the more common observation of expansion in viscoelastic liquid jets.

4312 LINEARIZED SUPERSONIC FLOW IN A JET OR IN A NEARLY CYLINDRICAL TUBE. M.Marini.
RC Accad. Naz. Lincei (Italy), Vol. 28, No. 6, 802-6 (June, 1960).
In Italian.

Axially symmetric perturbations of uniform supersonic flow are considered, with boundary conditions imposed at the surface of a cylinder. It is shown how these boundary conditions can be satisfied with the help of a suitable arrangement of singularities ("pseudo-sources") along the axis. O.Penrose

4313 THEORY OF RECTIFIED DIFFUSION OF MASS INTO GAS BUBBLES. Din-Yu Hsieh and M.S.Plesset.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 206-15 (Feb., 1961).

The problem considered is the behaviour of a gas bubble in a liquid saturated with dissolved gas when oscillating pressures are imposed on the system. This situation is encountered in experiments on cavitation and in the propagation of sonic and ultrasonic waves in liquids. Since gas diffuses into the bubble during the expansion half-cycle in which the pressure drops below its mean value, and diffuses out of the bubble during the compression half-cycle in which the pressure rises above its mean value, there is no net transfer of mass into or out of the bubble in first order. There is, however, in second order a net inflow of gas into the bubble which is called rectified diffusion. The equations which determine the system include the equation of state of the gas in the bubble, the equation of motion for the bubble boundary in the liquid, and the equation for the diffusion of dissolved gas in the liquid. In the solution presented here, the acoustic approximation is made; that is, the amplitude of the pressure oscillation is taken to be small. It is also assumed that the gas in the bubble remains isothermal throughout the oscillations; this assumption is valid provided the oscillation frequency is not too high. Under these conditions one finds for the mean rate of gas flow into the bubble the expression

$$\langle dm/dt \rangle = (8\pi/3)DC_\infty R_0(\Delta P/P_0)^2,$$

where D is the diffusivity of the dissolved gas in the liquid, $C_\infty$ is the equilibrium dissolved gas concentration for the mean ambient pressure $P_0$, $R_0$ is the mean radius of the bubble, and $\Delta P$ is the amplitude of the acoustic pressure oscillations. It may be remarked that the most important contribution to the rectification effect comes from the convection contribution to the diffusion process.

4314 A CONTRIBUTION TO THE THEORY OF CAUCHY–POISSON WAVES AT SLOPING BANKS.
B.N.Rumyantsev.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 2, 287-9 (Nov. 11, 1960). In Russian.

The elevation of the free surface is expanded in a series of stationary waves. Expressions for the amplitudes are obtained in the form of series which are simplified in the limit of high frequencies. [English translation in: Soviet Physics–Doklady (USA)]. R.Eisenschitz

4315 A CONTRIBUTION TO THE THEORY OF FREE FINITE OSCILLATIONS OF THE SURFACE SEPARATING TWO UNBOUNDED LIQUIDS OF DIFFERENT DENSITIES SUBJECT TO GRAVITY. Ya.I.Sekerzh-Zen'kovich.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 51-4 (Jan. 1, 1961). In Russian.

The non-linear terms in the equations of wave motion are made proportional to a small perturbation parameter, so that the perturbation of the familiar solutions of the linear wave equation is obtained in powers of this small quantity. Solutions are obtained involving the third power of the perturbation parameter. [English translation in: Soviet Physics–Doklady (USA)]. R.Eisenschitz

4316 THE MEASUREMENT OF RIVER FLOW BY THE USE OF UNDERWATER SOUND.
G.E.Miller, W.F.Richardson and N.Serotta.
IRE internat. Convention Record (USA), Vol. 8, No. 6, 246-54 (1960).

A survey of presently used methods of measuring river flow is presented together with the results of a study of the use of acoustic signals for this purpose. This study disclosed several acoustic problems associated with the water path which must be overcome before a reliable acoustic flowmeter can be realized. To obtain flow velocity from acoustic signals, it is necessary that these signals be transmitted both upstream and downstream. However, this study showed that the acoustic properties of the water could change from one transmission to the next, thus giving erroneous velocity readings. A system was proposed and built which allows for simultaneous upstream and downstream transmission, thereby eliminating the effects caused by the changing acoustic properties of the water path. This system is described and the results of some preliminary measurements are given.

4317 SURFACE TENSION AT THE INTERFACE BETWEEN TWO GASEOUS PHASES AT HIGH PRESSURES.
D.S.Tsiklis and Yu.N.Vasil'ev.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 2, 394-7 (Jan. 11, 1961). In Russian.

The interface tension between $C_2H_4$ and He at 13°, 16° and 18°C and in the pressure range 200-720 kg/cm$^2$ was determined using the capillary-rise method (see also Abstr. 2421 of 1951). The apparatus used is described and illustrated. It was found that the interface tension between two gaseous phases increases considerably with pressure. [English translation in: Soviet Physics–Doklady (USA)]. F.Lachman

4318 THE DAMPING OF VIBRATORY MOTION BY SOAP FILMS. E.J.Burcik and R.C.Newman.
J.Colloid Sci. (USA), Vol. 15, No. 4, 383-5 (Aug., 1960).

The damping effect of a soap film between the coils of a cylindrical helical vibrating spring was measured. The shear dependence of the viscosity affected the damping ratio. The observation of a maximum in the damping ratio as a function of the concentration of sodium laurate solutions, ranging from 0.10 N to 0.035 N, is explained, on the basis of the diffusion of the surface-active agent to the interface during expansion of the film and its effect on surface tension. R.Schnurmann

4319 THE WAKE OF A MOVING DROP.
R.H.Magarvey and R.L.Bishop.
Nature (GB), Vol. 188, 735-6 (Nov. 26, 1960).

Photographs have been taken of the wakes of drops of organic liquids falling at terminal velocity through water, the wakes being rendered visible by the scrubbing of a water soluble dye out of the drops as they fall. Almost perfect symmetry is observed regardless of deviations from sphericity, and in the case of larger drops, gross oscillations of the drop do not appear to have much effect on the wake. A concise review of existing knowledge is included. T.C.Toye

# LIQUID STATE

*(Liquid helium is included under Low-Temperature Physics)*

4320 FLUCTUATIONS OF COORDINATION NUMBER IN LIQUID LEAD. Ya.I.Dutchak.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1251-2 (Oct., 1960). In Russian.

The formula derived by Prokhorenko and Fischer [Zhurnal Fizicheskoi Khimii, Vol. 31, 1245 (1957)] is used to calculate the fluctuations from the available X-ray data. Between 330 and 450°C $\Delta n/n$ increases from 0.19 to 0.27. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 10, 1186-7 (April, 1961)]. M.G.Priestley

4321 SOLUTION AT HIGH DENSITY TO THE BORN–GREEN EQUATION. A.A.Broyles.
J. chem. Phys. (USA), Vol. 34, No. 2, 359-61 (Feb., 1961).

A solution to the Born–Green integral equation with the Lennard-Jones potential at $v/v^* = n^{-1}a^{-3} = 0.9$ is presented. Its asymptotic form is found to be $1-38.9r^{-5}\sin(2\pi r-2.928)$, and its integral over the volume $\tau$ of the system is $\tau-2.06$. The value of $E'/RT$ is found to be $-2.6$ and of $pv/RT$ is 3.8. The magnitudes of these thermodynamic quantities are compared with those obtained by the Monte Carlo method.

4322 VIBRATIONAL RELAXATION IN LIQUIDS.
M.Fixman.
J. chem. Phys. (USA), Vol. 34, No. 2, 369-75 (Feb., 1961).

Attempts have been made to apply the binary collision theory of vibrational deactivation to the liquid phase. The change of collision frequency with density was approximately accounted for, but the transition probability per collision was assumed independent of density. This latter assumption is investigated here by an addition, to the direct intermolecular force, of the frictional and random forces of Brownian motion theory. It is found that the frictional force has negligible effect, but the random force makes low-energy collisions much more effective in causing transitions than is predicted for an isolated binary collision by the semiclassical theory of Zener, Landau and Teller. As a consequence, the isolated binary collision theory cannot be applied to liquids although it should be adequate for fairly dense gases. Probably the Brownian motion theory exaggerates the neighbour effects in liquids; the point is discussed.

4323 THEORY OF CLASSICAL FLUIDS: HYPER-NETTED CHAIN APPROXIMATION. IIIa. T.Morita.
Progr. theor. Phys. (Japan), Vol. 23, No. 1, 175-7 (Jan., 1960).

Corrections are made to earlier papers by the author on classical liquids (Abstr. 14616-17 of 1960) which result, inter alia, in a new and relatively simple integral equation for the radial distribution function. The linearized version of this equation is the same as the linearized Born–Green equation. However, it is hoped that the full equation will be more accurate. R.O.Davies

4324 INVESTIGATION OF PERIODIC DISCONTINUITIES IN THE MUTUAL POTENTIAL ENERGY OF MOLECULES OF WATER AND SOME POLYHYDRIC ALCOHOLS.
M.M.Qurashi and A.K.M.Ahsanullah.
Brit. J. appl. Phys., Vol. 12, No. 2, 65-72 (Feb., 1961).

The inter-molecular energy of activation of viscous flow was measured at close intervals of 2 to 5 deg C for glycerol, ethylene glycol and thrice-distilled water, using the logarithmic derivative of the Andrade (1934) equation, namely,

$$\frac{\Delta \ln \eta}{\Delta T} = -\frac{\epsilon/k}{T^2}.$$

In the case of water and ethylene glycol, the temperature was controlled to 0.002 and 0.005 deg C respectively, and the temperature intervals measured with a calibrated Beckmann thermometer. By maintaining a corresponding accuracy in the viscosity measurement the values of $\epsilon/k$ for water are reproducible to 0.1% in the temperature range from 6 to 45° C and to 0.3% from 45 to 72° C. The results when plotted against temperature indicate a step-like variation of the energy $\epsilon$, the repetition interval between steps being 25 deg C for glycerol, 12 deg C for ethylene glycol, and 6.5 ± 0.2 deg C for water. The drop between successive steps in water is sharp, extending only slightly more than the measuring interval of 2 deg C, and each step is flat within the limits of experimental error. The energy interval $\Delta\epsilon$ between steps is not constant, but decreases steadily towards higher temperatures. The average value of this interval $\Delta\epsilon$ is of the order of 80 k, i.e. 0.007 eV, and is much smaller than the thermal energy kT, but is of the same order as the fine structure observed in the OH absorption of water at 3300 $cm^{-1}$. The temperature variation found for $\epsilon/k$ is compared with the graph calculated from the viscosity data of Bingham and Jackson (1918-19) on water, and fair agreement is obtained when the 2 deg C measuring interval of the present experiments is smeared out to 6 deg C.

4325 QUASI-LATTICE MODEL OF RECIPROCAL SALT SYSTEMS. A GENERALIZED CALCULATION.
M.Blander.
J. chem. Phys. (USA), Vol. 34, No. 2, 432-8 (Feb., 1961).

A generalized statistical–mechanical calculation of the solution thermodynamics of the reciprocal molten salt system $A^+$, $B^+$, $C^-$, and $D^-$ dilute in $A^+$ ions is made. The calculation is based on the quasi-lattice model of reciprocal salt systems and treats the problem as an order–disorder problem. Associations of the $A^+$ and $C^-$ ions as

$$A^+ + C^- \rightleftharpoons AC \quad (A)$$
$$AC + C^- \rightleftharpoons AC_2^- \quad (B)$$
$$AC_2^- + C^- \rightleftharpoons AC_3^= \quad (C)$$

are taken into account. In terms of the conventional equilibrium constants, $K_1$, $K_2$, and $K_3$ for (A), (B), and (C) respectively,

$$K_1 = Z(\beta_1 - 1) \quad (1)$$
$$K_1K_2 = \frac{Z(Z-1)}{2!}(\beta_1\beta_2 - 2\beta_1 + 1) \quad (2)$$
$$K_1K_2K_3 = \frac{Z(Z-1)(Z-2)}{3!}(\beta_1\beta_2\beta_3 - 3\beta_1\beta_2 + 3\beta_1 - 1), \quad (3)$$

where Z is the quasi-lattice coordination number, $\beta_j = \exp(-\Delta A_j/kT)$ and $\Delta A_j$ may be termed a specific bond free energy of the jth $C^-$ ion and is the specific Helmholtz free energy change for the formation of the jth bond. Equations (1), (2), and (3) demonstrate the surprising fact that the higher order association constants are dependent on the magnitude of the lower order association constants not only through the factor containing Z but also through the values of the $\beta_i$ for the lower association constants. If $\beta_1 = \beta_2 = \beta_3 = \cdots$ etc., the equations reduce to the statistical ratios of Bjerrum. The higher association constants can be shown to be smaller for a case in which the bonding is directional (e.g. linear $AC_2^-$), than if they are nondirectional, as in eqs. (2) and (3), even if the bond free energies are equal in the two cases.

4326 PAULING'S MODEL AND THE THERMODYNAMIC PROPERTIES OF WATER. H.S.Frank and A.S.Quist.
J. chem. Phys. (USA), Vol. 34, No. 2, 604-11 (Feb., 1961).

A statistical-thermodynamic treatment is given of the model for liquid water recently proposed [Hydrogen bonding. Edited by D.Hadzi. L.Pauling. p.1. London: Pergamon Press (1959); The nature of the chemical bond. L.Pauling. New York: Cornell University Press (1960), 3rd Ed., p. 472] in terms of a variable distribution of water molecules between the two states — framework water and interstitial water — for which this model provides. This treatment shows that, with simple assumptions, the model can give a satisfactory representation of the P-V-T properties of water over limited ranges of temperature and pressure. The properties (enthalpies and entropies) which are derived for framework and interstitial water, respectively, also seem physically reasonable. The simple model is less successful in representing the heat capacity of water and the partial molal properties of nonpolar solutes. The fact that water is a liquid, however, requires that some molecules be in a "third state", and it is suggested that, if this third state is taken into consideration, the shortcomings of the simple model can be remedied. Adoption of the Pauling model would seem to have as a corollary the likelihood that the structural "transition", purportedly found in liquid water just above 30° C, may be real.

4327 DENSITY OF LIQUID OXYGEN ON THE SATURATION CURVE. D.L.Timrot and V.P.Borisoglebskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1729-32 June, 1960). In Russian.

Measurements of the density are presented and compared with the published data. [English translation in: Soviet Physics — JETP (USA), Vol. 11, No. 6, 1248-50 (Dec., 1960)].

4328 COMPOSITION DEPENDENCE OF THE THERMAL CONDUCTIVITY OF REGULAR SOLUTIONS.
R.J.Bearman and V.S.Vaidhyanathan.
J. chem. Phys. (USA), Vol. 34, No. 1, 264-5 (Jan., 1961).

It is demonstrated from the statistical mechanics of transport processes that the product $\kappa\eta$ of the coefficients of thermal conductivity and viscosity may be expected to be independent of composition in regular solutions. The conclusion is verified for the system benzene–carbon tetrachloride.

4329 APPROXIMATE THECRY OF TRANSPORT IN SIMPLE DENSE FLUID MIXTURES.
S.A.Rice and A.R.Allnatt.
J. chem. Phys. (USA), Vol. 34, No. 2, 409-20 (Feb., 1961).

The theory of transport proposed by Rice and Kirkwood (Abstr. 904 of 1960 is extended to the case of multicomponent systems. As in the previous case, the intermolecular force contributions to the shear and bulk viscosities and the thermal conductance are displayed as functions of the diffusion coefficient and the thermodynamic properties of the mixture. The self-diffusion coefficient is related to the intermolecular forces and molecular distribution function, thereby completing the molecular basis of the computation. Formulae are also given for the thermal diffusion factor and the heat of transport. The theory presented predicts a form of volume fraction mixing. For example, the shear viscosity becomes

$$\eta = (v_1^*/v)^2\eta_1^* + (v_2^*/v)^2\eta_2^* + 2(v_1^*v_2^*/v^2)\eta_{12}^*,$$

with $v_1^*$ and $v_2^*$ the volume of $N_1$ molecules of component one and of $N_2$ molecules of component two, respectively, at the same temperature and pressure as the mixture. The quantities $\eta_1^*$, $\eta_2^*$, $\eta_{12}^*$ are composition dependent so that the predicted mixing law is not pure volume fraction mixing except in the case of an ideal solution. The theory is compared with experimental measurements of the viscosity of benzene—carbon tetrachloride mixtures, and good agreement is found. The agreement between theory and experiment is dicsussed with reference to the mechanism of irreversibility.

4330 SELF-DIFFUSION OF NEARLY SPHERICAL MOLECULES. NEOPENTANE AND TETRAMETHYL SILANE. D.C.Douglass, D.W.McCall and E.W.Anderson.
J. chem. Phys. (USA), Vol. 34, No. 1, 152-6 (Jan., 1961).

Self-diffusion coefficients were measured for neopentane and tetramethyl silane by means of the nuclear magnetic resonance spin-

echo technique. Both pressure and temperature dependences were determined, thus allowing evaluation of energies and volumes of activation; neopentane, $E_D$ = 3.5 kcal/mole and $\Delta V‡$ = 31 $cm^3$/mole; tetramethyl silane, $E_D$ = 1.16 kcal/mole, and $\Delta V‡$ = 22 $cm^3$/mole. The numbers given for neopentane are average values as the ln D versus 1/T and ln D versus p plots were not straight lines. Kirkwood's theoretical relation for the self-diffusion coefficient of spherical molecules was tested for the quasi-spherical neopentane. At 0° C the theoretical value is $6 \times 10^{-5}$ $cm^2$/sec while the experimental value is $2.6 \times 10^{-5}$ $cm^2$/sec. The Kirkwood equation for the self-diffusion coefficient is discussed in detail.

4331 ERRATUM: SELF-DIFFUSION IN LIQUIDS: PARAFFIN HYDROCARBONS.

D.W.McCall, D.C.Douglass and E.W.Anderson.
Phys. of Fluids (USA), Vol. 4, No. 1, 162 (Jan., 1961).

See Abstr. 3208 of 1959. The volume of activation of n - $C_5H_{12}$ was remeasured and a higher value found.

4332 DENSITIES OF SOLUTIONS OF POTASSIUM IN LIQUID AMMONIA AND DEUTERO-AMMONIA.

C.A.Hutchison, Jr and D.E.O'Reilly.
J. chem. Phys. (USA), Vol. 34, No. 1, 163-6 (Jan., 1961).

The densities were measured at −33.7°, 0.0°, and 20.0° C over a concentration range from 0 to 1.2 mole $litre^{-1}$. The correlation of these results with paramagnetic resonance measurements is discussed in terms of a cavity trapping model.

4333 HEATS OF MIXING IN LIQUID ALKALI NITRATE SYSTEMS. O.J.Kleppa and L.S.Hersh.
J. chem. Phys. (USA), Vol. 34, No. 2, 351-8 (Feb., 1961).

The enthalpies of mixing in binary liquid alkali nitrate systems were measured, and are all negative. It is found that the magnitude of the molar mixing enthalpy ($\Delta H^M$) increases in a regular fashion with increasing difference in size between the two participating cations, according to the following approximate relation

$$\Delta H^M \cong -X(1-X)\,U[(d_1-d_2)/(d_1+d_2)]^2$$

Here X and (1-X) are the mole fractions of the two components, U is the lattice energy of the mixture, while $d_1$ and $d_2$ are the interionic distances characteristic of the two pure components. The results are in accord with the view that in these systems the principal source of the enthalpy of mixing is the reduction in Coulombic repulsion between the second nearest neighbour cations. For binary systems with negative enthalpies of mixing of the order of RT there is evidence for short-range order among the cations.

4334 INTERPRETATION OF VISCOSITY DATA FOR CONCENTRATED POLYMER SOLUTIONS.

H.Fujita and A.Kishimoto.
J. chem. Phys. (USA), Vol. 34, No. 2, 393-8 (Feb., 1961).

An empirical viscosity versus concentration relation for concentrated polymer solutions is derived in terms of a simple free volume theory, and its applicability is tested with some available data for amorphous polymer+solvent systems. It is found that the derived relation fits well those data over the range of polymer concentrations so concentrated that interchain entanglements occur to form a weak network structure throughout the solution. In the region of relative low polymer concentrations, however, it shows deviation of a common feature from the experimental results. Two temperature-dependent parameters are contained in the viscosity equation derived; one is characteristic of the polymer species and the other is dependent upon the particular combination of polymer and diluent. These parameters are evaluated from comparisons with experimental data, and their variations with temperature are discussed.

4335 ON THE QUESTION OF THE SOLUBILITY OF RARE GASES IN MOLTEN SALTS. H.U.Woelk.
Nukleonik (Germany), Vol. 2, No. 7, 278-9 (Dec., 1960). In German.

An attempt is made to relate the free volume of a molten salt with its ability to dissolve gas. As the free volume increases with temperature, the solubility of monoatomic gases, such as the rare gases, increases also in molten salts which do not contain molecular associations and complexes. It is thus shown that a straight-line relationship holds for the solubility constants of the rare gases with respect to the free volume of molten KCl, KBr, and KI, but not of molten $KNO_3$, where presumably molecular complexes are formed in the liquid phase. With regard to binary systems the less pronounced maximum of the gas solubility curve for NaCl—KCl than for KCl—$PbCl_2$ must probably be ascribed to the greater tendency for complex formation in the latter. R.Schnurman

4336 SIGNAL AMPLITUDE AND PHASE FLUCTUATIONS INDUCED BY SURFACE WAVES IN DUCTED SOUND PROPAGATION. J.A.Scrimger.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 239-47 (Feb., 1961).

The effects of surface waves on sound propagated from a continuous wave source over a range of 300 ft in water depth 10 ft have been examined. It is found that the surface waves induce regular amplitude and phase fluctuations in the received signal. The dependence of the amount of amplitude and phase fluctuation on crest to trough height of the surface waves has been obtained for acoustic frequencies in the range 1 to 10 kc/s. Frequency spectra of the fluctuations, for values of the ratio of sound wavelength (λ) to wave height (A) above 18, are the same as the surface wave spectra. For values of λ/A less than 18 the fluctuation spectra are broader and show well-defined second and sometimes third harmonic components. Wave packet experiments in which the bow wave of a small boat is propagated across the length of the otherwise calm duct surface show that in the case of the uniformly rough surface the fluctuations are produced only by surface waves near the source and near the receiver.

4337 DISTORTION OF THE ULTRASONIC WAVEFORM OF FINITE AMPLITUDE IN VARIOUS LIQUIDS.

I.G.Mikhailov and V.A.Shutilov.
Akust. Zh. (USSR), Vol. 6, No. 3, 340-6 (1960). In Russian.

The optical method of measuring ultrasonic waveform distortion was used to determine nonlinear parameters of liquids. Formulae are given for calculating the rate of deformation of the wave profile of finite amplitude and of the ratio of coefficients in nonlinear equations of state of liquids. The results are given for acetone, benzine, benzene, water, glycerine, 1,2-dichloroethane, methyl alcohol, chloroform, carbon tetrachloride, ethyl alcohol. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 340-6 (Jan.-March, 1961)]. A.Tybulewicz

4338 MEAN FREE PATH AND ULTRASONIC VIBRATIONAL RELAXATION IN LIQUIDS AND DENSE GASES.

W.M.Madigosky and T.A.Litovitz.
J. chem. Phys. (USA), Vol. 34, No. 2, 489-97 (Feb., 1961).

Measurements of ultrasonic absorption and velocity in $CO_2$ yielded values of the vibrational relaxation times over a range of densities from 400 to 610 amagats at 25° C and 50.2° C. On the basis that only binary collisions are important it is found that the Enskog theory for determining collision times in the dense fluid failed to account for the results. Application of the Eyring—Hirschfelder cell model of the liquid accounted well for the density dependence of the relaxation frequency but gave values of mean free path which were too large. It is proposed that for mean free path calculations a realistic cell model must not use fixed walls as the Eyring and Hirschfelder model does but rather moving walls. When this modification is included excellent agreement is obtained for both $CO_2$ and $CS_2$. It is further shown that attractive forces do not play the role in determining the collision efficiencies in a liquid or dense gas that they do in the dilute gas. After correcting for the reduced effect of attractive forces, it is found that the collision efficiencies for the dilute gas agree with values obtained for the liquid and dense gas.

4339 DISPERSION OF ULTRASONIC VELOCITY IN ELECTROLYTES. B.Krishnamurty.
J. sci. industr. Res. (India), Vol. 19B, No. 2, 74-5 (Feb., 1960).

Experiments have been carried out to examine the dispersion of ultrasonic velocity in electrolytes in order to verify theoretical suggestions made previously by the author. The experiments confirmed theoretical expectations that the nature of the dispersion is such that a velocity maximum is exhibited at a particular frequency. Also in conformity with theory, with one exception, there was a definite decrease of the amount of dispersion with increasing concentration of electrolyte. However the theoretical suggestion that the frequency at which a velocity maximum occurs moves to higher values for higher concentrations was not borne out by experiment, which showed the frequency of maximum velocity to be a constant value at all concentrations. B.Brown

4340 ULTRASONIC RELAXATION AND AXIAL-EQUATORIAL ISOMERIZATION IN METHYL CYCLOHEXANE.
.E.Piercy.
. Acoust. Soc. Amer., Vol. 33, No. 2, 198-206 (Feb , 1961).

The ultrasonic absorption and velocity of dilute solutions of methyl, chloro-, and bromocyclohexane in xylene were measured over the range 0.6 to 25 Mc/s and 65° to 95°C. The frequency dependence of the absorption in all cases is that of a single relaxation process. The concentration dependence of the relaxation parameters is consistent with the mechanism being the interchange of axial and equatorial chair isomers, while the temperature dependence yields a difference in enthalpy and entropy between isomers of methyl cyclohexane of 3.5±0.7 kcal $mole^{-1}$ and 4.0±1.1 cal $mole^{-1}$ $deg^{-1}$ C, respectively, and an activation energy for the conversion of axial into equatorial isomers of 10.9±0.8 kcal $mole^{-1}$ for methyl cyclohexane and 12±2 kcal $mole^{-1}$ for chloro- and bromocyclohexane. There is no significant change in these values for methyl cyclohexane when the solvent is changed to nitrobenzene or n-butyl alcohol, indicating that intermolecular processes do not make an appreciable contribution, and that the difference in volume between isomers can be neglected in the calculations. The conversion of axial into equatorial isomers is found to be unimolecular, and a mode of vibration of the molecule similar to either the $A_{1g}$ or $E_u$ modes of cyclohexane is suggested for the path of this reaction.

4341 THE FINE STRUCTURE OF THE RAYLEIGH SCATTERING OF LIGHT IN SOLUTIONS AND THE DISPERSION OF HYPERSONIC VIBRATIONS.
L.V.Lanshina and M.I.Shakhparonov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 3, 624-6 (July 21, 1960).
In Russian.

The fine structure of the Rayleigh scattering of 4358 and 4046 A lines in acetone—water and methanol—water solutions at 25°C indicated density and concentration fluctuations in the acetone—water system and density fluctuations only in the methanol—water system. The velocity of propagation of hypersound in the acetone—water system at $f \cong 0.6 \times 10^{10}$ c/s, and in the methanol—water system at $f \cong 0.5 \times 10^{10}$ c/s, showed negative dispersion due to the structural relaxation of water. A.Tybulewicz

4342 THEORY CF LIGHT SCATTERING BY THIN RODLIKE MACROMOLECULES IN A LIQUID SUBJECTED TO SHEAR. K.Okano and E.Wada.
J. chem. Phys. (USA), Vol. 34, No. 2, 405-8 (Feb., 1961).

The light scattering by thin rodlike particles in a liquid subjected to shear is calculated on the basis of the Rayleigh—Gans treatment. The calculations are made for both unidirectional laminary flow and for flow of periodically alternating direction. The calculation is carried out by two methods: the interference factor P is expressed in terms of a power series of G/D, where G and D are the rate of shear and the rotatory diffusion constant, respectively, of the rod rotating around its minor axis. This treatment is applicable to sufficiently low G/D values. The result for a very wide range of rate of shear is obtained by using the Peterlin distribution function of particle axis. Numerical calculation shows that both results agree in a region of G/D below about two if the axial ratio is large enough. The theoretical results appear to agree with the experimental ones.

4343 REFLECTION SPECTRA AND ABSOLUTE INFRARED INTENSITIES IN PURE LIQUIDS: BENZENE, CHLOROFORM, BROMOFORM, CARBON DISULFIDE, AND CARBON TETRACHLORIDE.
P.N.Schatz, S.Maeda, J.L.Hollenberg and D.A.Dows.
J. chem. Phys. (USA), Vol. 34, No. 1, 175-81 (Jan., 1961).

Reflection spectra were studied in the infrared region. On using a method developed in this work, absolute intensities of the vibrational transitions involved were obtained from the experimental data. The results are in reasonable agreement with intensities obtained from dispersion studies except for the case of carbon disulphide. The benzene intensity obtained is in disagreement with the value from absorption measurements on the pure liquid.

4344 INTERPRETATION OF THE ELECTRONIC AND VIBRATION ABSORPTION SPECTRA OF URANYL NITRATES. L.V.Volod'ko, A.N Sevchenko and D.S.Umreiko.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 560-3 (Nov. 21, 1960). In Russian.

Reports an analysis of frequencies observed in the infrared absorption spectra of solutions of uranyl dinitrate hexahydrate and of uranyl trinitrate in acetone with special reference to the frequencies due to the $NO_3^-$ anion. It was found that the $NO_3^-$ vibration frequencies obtained from the fluorescence spectra coincide with a number of the frequencies observed in the infrared absorption spectrum. Unlike these absorption spectra, the electronic absorption spectra undergo a considerable change when dinitrate is converted to trinitrate; the four long-wavelength bands with maxima 21 404, 22 114, 22 831 and 23 545 $cm^{-1}$ undergo a considerable increase, whereas no substantial changes are noticed in the remaining portion of the visible spectrum. [English translation in: Soviet Physics—Doklady (USA)]. F.Lachman

4345 OPTICAL SPECTRUM OF THE SONOLUMINESCENCE EMITTED BY CAVITATED WATER.
D.Srinivasan and L.V.Holroyd.
J. appl. Phys. (USA), Vol. 32, No. 3, 446-9 (March, 1961).

The optical spectrum of the weak luminescence produced when water is irradiated by an intense ultrasonic beam has been determined. Water saturated with argon, helium, oxygen, or nitrogen was studied with the use of 800 kc/s radiation. The spectral distribution of the luminescence was measured with a spectrometer and photon counter combination in the interval 2800-5500 A. The spectra are continuous and correspond to that of a blackbody. For dissolved argon and helium the equivalent temperature is 11 000°K, whereas for dissolved oxygen and nitrogen the temperature is 8800°K.

4346 SPACE-TIME ANALYSIS OF THE SONOLUMINESCENCE EMITTED BY CAVITATED WATER.
R.Q.Macleay and L.V.Holroyd.
J. appl. Phys. (USA), Vol. 32, No. 3, 449-53 (March, 1961).

Measurements of the intensity versus phase angle distributions of the sonoluminescence of cavitated water have been made at 400, 600, and 1200 kc/s. Peak acoustic pressure ranged from 1.8-2.8 atm. In agreement with the theory of Noltingk and Neppiras, the emission was found to take place in the compression phase. Calculation of the intensity versus phase angle distribution based on the Noltingk—Neppiras theory gave results which agreed well with experiment.

4347 LUMINESCENCE IN A SCINTILLATION SOLUTION EXCITED BY $\alpha$ AND $\beta$ PARTICLES AND RELATED STUDIES IN QUENCHING. I.B.Berlman.
J. chem. Phys. (USA), Vol. 34, No. 2, 598-603 (Feb., 1961).

The relative intensity of the light pulses produced by $\alpha$ and $\beta$ particles in a scintillating solution of 2, 5-diphenyloxazole (PPO) in xylene was investigated as a function of the concentration of the solute. The $\alpha/\beta$ ratio is substantially smaller than that found in organic plastic scintillators. From the data the dynamic quenching parameter is calculated. Several independent experiments, i.e., measurements pertaining to mean lifetime of fluorescence, u.v. excitation, and pulse heights, were undertaken to study the mechanisms of quenching by oxygen in a scintillating solution. The best interpretation of the oxygen effect is consistent with the existence of dynamic quenching of the solvent and of the solute.

4348 NEW LIQUID SCINTILLATORS.
Kh.V.Protopopov, Kh.A.Arslanov, S.V.Butomo and T.V.Timofeeva.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 24-8 (March-April).
In Russian.

The possibility of using methylantranilate, $\beta$-naphtol ethers, and other very easily available substances as activators for liquid scintillators was investigated. The scintillation efficiency of methylantranilate dissolved in toluene was found to increase considerably upon the introduction of naphthalene. Oxygen was successfully removed from liquid scintillators by mens of $CO_2$. A solution of 2.5 g/litre of methylantranilate in a mixture of 3% methanol, 15% naphthalene and 82% toluene showed, after removal of oxygen, an improvement of 1.26 with respect to a solution of 5 g/litre of terphenyl in toluene. [English translation in: Instrum. exper. Tech. (USA), No. 2, 200-4 (March-April, 1958; publ. April, 1959)].

4349 ON THE LUMINESCENCE MINIMUM IN CERTAIN SCINTILLATOR SOLUTIONS.
J.M.Nosworthy, J.L.Magee and M.Burton.
J. chem. Phys. (USA), Vol. 34, No.1, 83-9 (Jan., 1961).

Several scintillator solutions were examined for the luminescence minimum previously reported for the case of $Co^{60}$ gamma-irradiated cyclohexane + benzene + p-terphenyl with oxygen present. The minimum is shown to be dependent on the nature of the solvents

and of the quencher. A satisfactory interpretation of the data involves the notion of energy transfer from molecules of the less-efficient ("common") solvent to the molecules of the more efficient ("better") solvent and thence to the scintillator. The latter transfer appears to involve more than one molecule of the solvent. A suggested model of the quenching process explains the existence of two classes of quenchers, one of which does not give a minimum.

4350 QUENCHING OF SENSITIZED FLUORESCENCE IN SOLUTIONS. B.Ya.Sveshnikov and L.A.Limareva.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 807-10 (Aug. 1, 1960). In Russian.

Fluorescence of rhodamine B solutions in methanol or glycerine, excited with a mercury line at 546 mμ, was quenched with trypaflavine. Quenching depended on the duration of fluorescence and was independent of the viscosity of the solution. This quenching was not due to diffusion processes or to the presence of a foreign absorbing substance, since there was no overlapping between the fluorescence spectrum of rhodamine B and the absorption spectrum of trypaflavine. Reports also a discovery of quenching, by KI, of fluorescence of trypaflavine and rhodamine B solutions in methanol; fluorescence was excited with a mercury line at 436 mμ in the case of pure trypaflavine solutions or mixed trypaflavine–rhodamine B solutions, and with the line at 546 mμ in the case of pure rhodamine B solutions. [English translation in: Soviet Physics–Doklady (USA), Vol. 5, No. 4, 834-6 (Jan.-Feb., 1961)]. A.Tybulewicz

4351 DETERMINATION OF THE ANISOTROPY OF BOND-POLARIZABILITY OF LIQUIDS USING FLOW-BIREFRINGENCE MEASUREMENTS. W.Philippoff.
J. appl. Phys. (USA), Vol.31, No. 11, 1899-1906 (Nov., 1960).

The contributions of the C–C and C=C bonds and the $CH_2$ link to the anisotropy of the polarizability of a liquid are considered. Experimental results obtained for alcohols using an apparatus previously described [Philippoff and Gaskins, Industr. engng Chem. (USA), Vol. 51, No. 7, 871 (July, 1959); Journal of Applied Polymer Science, Vol. 2, 143 (1959)] are given together with those taken from the literature. The alcohols examined are heptyl, octyl, nonyl, decyl, undecyl, dodecyl, tetradecyl, hexadecyl, ricinoleyl, hexadecane, undecylenic acid and undecylic acid. The anisotropy q and the mean polarizability $\alpha_m$ are calculated for each alcohol from the theory of Raman and Krishnan (Abstr. 1878 of 1928), which was corrected by Paldikar (Abstr. 3190 of 1936). The values of q and $\alpha_m$ are found to satisfy the equations $q = -0.57 + 0.44x$, and $c_m = 2.00 + 1.79x$, where x is the number of carbon atoms. The values of $\alpha_1$ and $\alpha_2$, for the C–C bond are 0.81 $A^3$ and 0.37 $A^3$ respectively, where $\alpha_1$ and $\alpha_2$ are the principal polarizabilities of the molecules which are assumed to be ellipsoids of revolution. These compare well with the values of Bolton (Abstr. 3951 of 1955). For the $CH_2$ group, $\alpha_1$ and $\alpha_2$ are 2.08 $A^3$ and 1.64 $A^3$ respectively. The value of q for the C=C bond is 1.29 $A^3$. Saunders' results [Trans. Faraday Soc. (GB) Vol. 53, Pt 6, 860 (June, 1957)] for polyethylene and polymethylene are checked but not confirmed. The present results are compared with those obtained by measurements of the Kerr effect and the depolarization of scattered light. It is concluded that they are reasonable. H.G.Jerrard

4352 A NEW RELATION BETWEEN THE COLE–COLE DISTRIBUTION PARAMETER [α] AND TEMPERATURE.
B.L.Narayana.
J. sci. industr. Res. (India), Vol. 19B, No. 3, 114-15 (March, 1960).

The relation $\alpha = Ae^{B/T}$ has been found for polar liquids. T is the absolute temperature and A and B constants. J.H.Mason

4353 DIELECTRIC RELAXATION OF ALIPHATIC CHAIN-MOLECULES IN DILUTE SOLUTION.
G.Klages and R.Langpape.
Z. Naturforsch. (Germany), Vol. 15a, No. 11, 964-74 (Nov., 1960). In German.

Dielectric absorption measurements were made on over twenty chlorine-substituted aliphatic hydrocarbons in dilute solution in benzene, and mostly also in n-heptane. Wavelengths used were 3.06, 1.56 and 0.71 cm. Results are discussed in conjunction with existing measurements at 3.46 m wavelength (Abstr. 2990 of 1939; 19149 of 1960). In most cases the maximum reduced absorption does not reach the value of 0.5 as for a Debye curve, and its deviations from this value are discussed in terms of multiple relaxation times. For molecules with terminal polar groups, the effects of mobility of these groups are clearly shown. The theory of free rotation of these groups, due to Budo (Abstr. 5037 of 1938), does not fit details of the measurements, and probable complications are discussed. In molecules with polar side groups, the relaxation spectrum becomes narrower the further these groups are from the end of the molecule and good agreement with a Fröhlich distribution of relaxation times is obtainable. Dichlorides with two terminal polar groups and nearly spherical chlorides of small molecular volume are also discussed. J.Sherida

4354 THE EFFECT OF DISSOLVED GASES ON THE ELECTRICAL CONDUCTION AND BREAKDOWN OF INSULATING OIL. H.Tropper.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 144-50 (Feb., 1961).

An experimental study was made of the effect of dissolved air on the electrical conduction and breakdown of insulating oil. It was found that the breakdown of degassed oil is preceded by an appreciable conduction current which is accompanied by fluorescence of the highly stressed oil. It was shown that both the conduction current and the breakdown voltage, particularly the latter, are affected by the residual oxygen dissolved in the oil. Other observations are concerned with the change in breakdown voltage when the air content of the oil is increased up to its saturation value at atmospheric pressure.

THE ELECTRICAL RESISTIVITY OF MONOCRYSTALLINE AND LIQUID BISMUTH. See Abstr. 3713

4355 ELECTRICAL CONDUCTIVITY OF LIQUID SELENIUM IN STRONG ELECTRIC FIELDS.
A.A.Andreev and A.R.Regel'.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2770-5 (Nov., 1960). In Russian.

Reports pulse measurements of the conductivity in fields up to $10^5$ V/cm between 180° and 350° C. The maximum effect of strong fields appeared on the introduction of 0.3% iodine into selenium. The dependence of the conductivity on the applied field agreed approximately with Frenkel's formula in fields greater than $10^4$ V/cm and seemed to be an extrapolation of the strong-field effect in solid amorphous selenium. [English translation in: Soviet Physics–Solid State (USA)]. A.Tybulewicz

4356 HALL EFFECT IN LIQUID AND SOLID MERCURY.
P.W.Kendall and N.E.Cusack.
Phil. Mag. (Eighth Ser.) (GB), Vol. 5, 100-1 (Jan., 1960).

The measured Hall coefficient for liquid Hg was in good agreement with the theoretical value assuming spherical Fermi surfaces, an isotropic relaxation time and two valence electrons per atom. It was independent of temperature from room temperature down to the freezing point. For solid samples $R_H$ was still negative, but it varied from sample to sample, and was probably anisotropic. C.Hilsum

4357 KNIGHT SHIFT OF THE NUCLEAR MAGNETIC RESONANCE IN LIQUID INDIUM.
C.P.Flynn and E.F.W.Seymour.
Proc. Phys. Soc. (GB), Vol. 76, Pt 2, 301-3 (Aug., 1960).

The shift in the liquid metal with respect to that in indium sulphate solution was found to be

$$[0.786 \pm 0.007 - (14 \pm 3) \times 10^{-5}(T - 170)]\%$$

in the range $170^\circ C < T < 360^\circ C$. $In^{115}$ and $In^{113}$ resonances were also observed in the supercooled liquid metal but not in the solid. E.F.W.Seymour

4358 OBSERVATION OF NUCLEAR MAGNETIC RESONANCE IN EMISSION. M.Pettie.
"Optics of all Wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 68-73. In German.

A flowing-liquid proton-resonance set-up using adiabatic fast passage and stimulated emission (see Abstr. 7319, 8160 of 1958) is described. J.G.Powles

4359 CONCENTRATION DEPENDENCE OF N.M.R. SPIN–LATTICE RELAXATION TIMES IN SOLUTIONS.
R.W.Mitchell and M.Eisner.
J. chem. Phys. (USA), Vol. 34, No. 2, 651-5 (Feb., 1961).

Spin–lattice relaxation times for protons in benzene, cyclohexane, chlorobenzene, bromobenzene, and o-dichlorobenzene in solution with carbon tetrachloride and carbon disulphide are empirically fitted to theoretical curves based on the Hill and molecular sphere models of molecular motion. The results indicate that the Hill model properly accounts for the variation of both the rotational and translational relaxation times with concentration of solute.

4360 NUCLEAR MAGNETIC RESONANCE STUDY OF THE PROTON TRANSFER IN WATER. S.Meiboom.
. chem. Phys. (USA), Vol. 34, No. 2, 375-88 (Feb., 1961).

Measurements of the nuclear relaxation in water are reported. he transverse relaxation rate ($1/T_2$) of the proton resonance is H dependent. The effect is shown to be due to a spin–spin splitting f the proton resonance by $O^{17}$ (spin 5/2), which is only partially veraged out by proton exchange. The increase of relaxation rate s observable in natural water (0.037% $O^{17}$), and becomes very ppreciable in water enriched in $O^{17}$. Additional information can e obtained by measuring relaxation rates in the presence of an .f. field $H_1$, using a method due to Solomon. A study of the width f the $O^{17}$ resonance as a function of pH is in quantitative agreement ith the results of the proton resonance. The observations provide direct determination of the rate constants of the exchange reactions:

$$H_2O + H_3O^+ \overset{k_1}{\rightarrow} H_3O^+ + H_2O \text{ and } H_2O + HO^- \overset{k_2}{\rightarrow} HO^- + H_2O.$$

It is found that $k_1 = (10.6 \pm 4) \times 10^9$ litre mole$^{-1}$ sec$^{-1}$ and $k_2 = (3.8 \pm 1.5) \times 10^9$ litre mole$^{-1}$ sec$^{-1}$. The spin–spin interaction etween H and $O^{17}$ in water is determined as $92 \pm 15$ c/s. In the ppendices, theoretical equations for the exchange contribution to he relaxation rate are derived.

4361 TEMPERATURE DEPENDENCE OF PROTON RELAXATION TIMES IN AQUEOUS SOLUTION OF PARAMAGNETIC IONS. II. $CrCl_3$.
T.H.Brown, R.A.Bernheim and H.S.Gutowsky.
J. chem. Phys. (USA), Vol. 33, No. 5, 1593-4 (Nov., 1960).

For Pt I see Abstr. 8362 of 1959. The proton $T_1$ and $T_2$ values at 20 Mc/s for chromic chloride solutions in water are given over he temperature range $-170^\circ$C to $0^\circ$C. A dependence of the relaxation times on thermal history is found for both the green and the blue modifications. It is supposed that the structure of the solvated species changes with time constants of minutes or hours depending on the temperature. An attempt is made to interpret these effects.

J.G.Powles

4362 TEMPERATURE DEPENDENCE OF THE PROTON SPIN–LATTICE RELAXATION TIME IN LIQUID BUTYL ALCOHOLS.
R.A.Bernheim, H.S.Gutowsky and I.J.Lawrenson.
J. chem. Phys. (USA), Vol. 34, No. 2, 565-9 (Feb., 1961).

The proton $T_1$ was measured by r.f. pulse methods at 20 Mc/s for n-butyl, iso-butyl, sec-butyl, and tert-butyl alcohol over their liquid range. The observed temperature dependences of $T_1$ correspond to activation energies of 3.9, 4.8, 5.2, and 7.3 kcal/mole, respectively, for the n, iso, sec, and tert alcohols. The $T_1$ results and a comparison of them with known dielectric dispersion data indicate that the spin–lattice relaxation is produced by molecular motions which are restricted by hydrogen bonding and steric effects to reorientations mainly about the C–O and C–C bonds of the heavy atom skeleton.

NUCLEAR ORIENTATION AND OVERHAUSER EFFECT.
See Abstr. 3944

NUCLEAR QUADRUPOLE RESONANCE. REVIEW. See Abstr. 4742

4363 TIME SPECTRA OF POSITRONS ANNIHILATING IN ORGANIC LIQUIDS CONTAINING HALOGENS.
J.H.Ormrod and B.G.Hogg.
J. chem. Phys. (USA), Vol. 34, No. 2, 624-7 (Feb., 1961).

Measurements were made of the mean life $\tau_2$, and the percent $I_2$, of positrons forming triplet positronium in propyl halides and in benzene–carbon tetrachloride solutions. The experimental variations of $I_2$ in the propyl halides can be predicted assuming a semiempirical equation of the form $100 - 4/3I_2 = AN_1 + 2.4N_2$, where A is the annihilation factor of the parent molecule and $N_1$ and $N_2$ are the per cent volumes of the parent and halide, respectively. A equal to 0.36 is needed for the propyl parent. This equation also predicts correctly the experimental values for the benzyl halides if A equal to 0.53 is used as the benzyl annihilation factor. The quenching of $I_2$ in the benzene–carbon tetrachloride solutions is much greater than that computed by the equation and the variation in quenching closely resembles that obtained in aqueous nitrate-ion solutions.

# MECHANICS OF GASES

4364 A ROTATING DISK VISCOMETER.
V.Mercea, J.Mercea and I.Ursu.
Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 2, 135-41 (1957). In Roumanian.

Two viscometers are described, one suitable for laboratory use and the other for demonstration. Both are based on the same principle and are useful for the continuous analysis of mixtures of gases. The essential part consists of two parallel disks, one facing the other. The first rotates with constant angular velocity, while the second, which is suspended freely above the first, is carried along by the viscous friction of the gas included between the two disks. Damping of rotational and transverse oscillations is produced by means of an oil or air damper. The angle of rotation of the suspended disk from the position of rest depends on the viscosity of the gas and on the distance between the disks. The sensitivity of the apparatus can therefore be controlled. The method of use is described, as well as the calibration data, in the case of the mixtures: $CH_4$–$H_2$, $CH_4$–$O_2$, $CH_4$–$CO_2$, $CH_4$–air. Good reproducibility and independence of flow is noted. The sensitivity, controllable to 1-2% (approximately), has been verified: it attains a precision of 1 to 2% (approximately).

S.Weintroub

4365 A RIGOROUS SOLUTION OF THE EQUATIONS [GOVERNING] THREE-DIMENSIONAL NONSTATIONARY FLOW OF GASES OF THE DOUBLE-WAVE TYPE.
L.V.Komarovskii.
Dokl. Akad Nauk SSSR, Vol. 135, No. 1, 33-5 (Nov. 1, 1960).
In Russian.

By "double wave" the author understands a pattern of motion which is fully specified in terms of two equations determining two components of local velocity. Solutions of the equations of motion of this type are obtained; they are not necessarily restricted to irrotational flow. [English translation in: Soviet Physics — Doklady (USA)].

R.Eisenschitz

4366 EXISTENCE OF SOLUTIONS OF ONE-DIMENSIONAL FLOW OF A REAL GAS J.Menkes.
Phys. of Fluids (USA), Vol. 4, No. 3, 360-61 (March, 1961).

Formal solutions to the equations of motion of the one-dimensional, unsteady flow of a viscous, compressible, heat-conducting gas are presented. The relationship between the existence of these solutions and the problem of hydrodynamic stability is discussed.

4367 TURBULENT FLOW IN A CIRCULAR PIPE WITH POROUS WALL. S.W.Yuan and E.W Brogren.
Phys. of Fluids (USA), Vol. 4, No. 3, 368-72 (March, 1961).

A theoretical investigation of an isothermal turbulent flow in a porous wall pipe with fluid injection or suction at the wall is made. An exact solution of the Reynolds equations, reduced to ordinary nonlinear differential equations with appropriate boundary conditions, is obtained. The axial velocity distribution is expressed as functions of velocity through the porous wall, the axial pressure gradient and the mixing length proportionality constant K. Experimental data are used in conjunction with the solution to calculate the values of K over a range of injection-to-main-stream velocity ratio. Good agreement is obtained between the present velocity profiles and such data.

4368 FRICTION AND HEAT EXCHANGE IN A COMPRESSIBLE TURBULENT BOUNDARY LAYER AT [THE SURFACE OF] A PLATE WITH MATTER BEING INJECTED.
Yu.V.Lapin.
Zh. tekh. Fiz. USSR , Vol. 30, No. 8, 984-93 (Aug., 1960). In Russian.

For abstract, see Abstr. 19181 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 920-8 (Feb., 1961)].

4369 FRICTION AND HEAT EXCHANGE IN COMPRESSIBLE TURBULENT BOUNDARY LAYERS DURING A CHEMICAL REACTION DUE TO ADMISSION OF A DIFFERENT SUBSTANCE. Yu.V.Lapin.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1227-37 (Oct., 1960).
In Russian.

A mixture of a chemically inert gas with oxygen is flowing past a porous wall through which combustible gas is supplied. In applying the equations of motion to boundary layers it is assumed

that the rate of combustion is so high that it takes place virtually in a single plane layer. The local concentration of the various components is then determined by the rate of diffusion. The distribution of concentrations and temperature is deduced. The resulting flow of momentum and energy through the solid–gas boundary is obtained and interpreted in terms of friction and a heat transfer coefficient. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 10, 1162-72 (April, 1961)].

R.Eisenschitz

4370 THE THEORY OF PLANE WAVES OF FINITE AMPLITUDE IN IDEAL GASES WITH VISCOSITY AND HEAT CONDUCTIVITY. W.Werner.

Ann. Phys. (Germany), Vol. 7, No. 1-2, 28-44 (1961). In German.

The equations of motion lead to a single partial differential equation of the fifth order. Three types of particular solution are presented and are applied in various physical contexts.

H.N.V.Temperley

## Shock Waves

4371 ENERGY TRANSFER TO A RIGID PISTON UNDER DETONATION LOADING.

A.K.Aziz, H.Hurwitz and H.M.Sternberg.

Phys. of Fluids (USA), Vol. 4, No. 3, 380-84 (March, 1961).

The flow following the impact of a plane detonation front, in a condensed organic explosive, on a rigid piston is obtained by a finite difference procedure. The equation of state $E = Pv/(\gamma - 1)$ is used for the gaseous explosion products with $\gamma$ equal to 2.5, 3.0, and 3.5. Explicit formulae for the piston motion are obtained analytically for $\gamma = 3$. The effects of the detonation parameters and the explosive-mass to piston-mass ratio on the terminal velocity of the piston and on the energy transmitted to the piston are described. For $\gamma = 2.5$ to 3.5, the terminal velocity of the piston depends almost entirely on the chemical energy released in the explosion and on the explosion-mass to piston-mass ratio, i.e. for a fixed chemical energy, the total energy transmitted to the piston is insensitive to the form of the detonation wave.

4372 PARAMETRIC STUDY OF THE CONICAL SHOCK TUBE. V.Josephson and W Hales.

Phys. of Fluids (USA), Vol. 4, No. 3, 373-9 (March, 1961).

A parametric study was made on the performance of a conical discharge shock generator. From these studies it has been possible to formulate general basic rules to be followed in designing a shock tube of this type capable of producing a single high-velocity shock at gas pressures varying from 25 to 2000 $\mu$. Typically, shocks of $M_S \cong 150$ have been produced in $D_2$ at 100 $\mu$ pressure

# GASEOUS STATE

4373 A METHOD FOR THE INTERFEROMETRIC ANALYSIS OF THREE-COMPONENT MIXTURES. W.Nebe.

"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 64-7. In German.

Outlines the theory of a method for determining the concentrations of three gases in a mixture by measurement of refractive index and mean dispersion.

G.F.Lothian

4374 THE PSEUDO-CRITICAL CONSTANTS OF GASEOUS MIXTURES. E.E.Daub.

Doshisha Engng Rev. (Japan), Vol. 10, No. 3-4, 129-40 (Dec., 1959).

The pseudo-critical constants for gaseous mixtures were determined graphically using the generalized compressibility curves with $Z_C$ as the third parameter. The accuracy of the $Z_C$ correlation for estimating the compressibility of gaseous mixtures by means of the pseudo-critical method was compared with that of the acentric factor correlation, and the acentric factor correlation was found to be superior. The pseudo-critical constants calculated from Joffe's equations were compared with the empirical values for these constants, and agreement is greatly improved in the case of mixtures of a hydrocarbon and a non-hydrocarbon if the linear combination is used for the van der Waal's constant b instead of the Lorentz combination.

A KINETIC EQUATION FOR RAPIDLY VARYING PROCESSES. See Abstr. 4593

SPECIFIC HEATS OF HELIUM VAPOURS BELOW 4.2°K. See Abstr. 4522

4375 VIBRATIONAL RELAXATION OF CARBON MONOXIDE IN THE SHOCK TUBE. D.L.Matthews.

J. chem. Phys. (USA), Vol. 34, No. 2, 639-42 (Feb., 1961).

The rate of approach to vibrational equilibrium of suddenly heated CO was studied using a shock tube and interferometer in the temperature range 2200-4900° K. Care was taken to ensure purity of the gas, so that the effect of impurities could be considered negligible. The measured relaxation times, which ranged nearly exponentially from 50 $\mu$sec at 2200° to 2 $\mu$sec at 4900°, agree fairly well with the results of Windsor et al., who covered the range 1400°-3000° using a somewhat different method. Both sets of measurements show satisfactory agreement with Landau–Teller theory as refined by Herzfeld et al. Separate experiments were performed with CO to which was added about 1% of $H_2$, $N_2$, $O_2$, $CO_2$, and $H_2O$, one at a time. $CO_2$ produced a slight reduction and $H_2O$ a very marked reduction in the relaxation time; the others produced no observable effect.

MEAN FREE PATH AND ULTRASONIC VIBRATIONAL RELAXATION IN LIQUIDS AND DENSE GASES. See Abstr. 4338

4376 SOUND ABSORPTION AND DISPERSION IN GASEOUS $N_2O_4$ ($NO_2$). G.Sessler.

Acustica (Internat.), Vol. 9, No. 2, 119-20 (1959). In German.

Reports results of measurements made at 20° C and 53° C using the method and interferometer described earlier (Abstr. 2899 of 1958; 19287 of 1960). The absorption and velocity are shown graphically as a function of f/p, ranging from $10^5$ to $10^8$ c/s per atom, at pressure p ranging from 1 to 200 torr. There are four absorption maxima; the interpretation of these maxima is discussed.

S.Weintroub

4377 THEORY OF BIREFRINGENCE INDUCED IN A COMPRESSED GAS MIXTURE BY AN ELECTRIC FIELD GRADIENT. S.Kielich.

Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys. (Poland), Vol. 8, No. 9, 637-44 (1960).

The theory due to Buckingham (Abstr. 7469 of 1959) is extended to multi-component systems and applied to compressed mixtures of polar gases, and of non-polar gases.

J.Hawgood

4378 INSTRUMENTAL EFFECTS IN INFRARED GAS SPECTRA AND SPECTROSCOPIC TEMPERATURE MEASUREMENTS. H.J Babrov.

J. Opt. Soc. Amer., Vol. 51, No. 2, 171-4 (Feb., 1961).

The effect of a most general spectrometer response function (slit function) on the measured transmission and emission of gases is investigated. It is shown that, although both the measured absorption and emission of hot gases are distorted by the slit function, the temperature determined by the infrared monochromatic radiation method is independent of the slit function. It is also shown that the condition for the invariance of the integrated transmission are much milder than those previously assumed.

4379 MEASUREMENTS OF INFRARED SPECTRAL EMISSIVITIES OF HOT CARBON DICXIDE IN THE 4.3$\mu$ REGION. R.H Tourin.

J. Opt. Soc. Amer., Vol. 51, No. 2, 175-83 (Feb., 1961).

Infrared spectral emissivities of hot carbon dioxide were determined by measurement of the infrared absorption spectra of gas samples heated under controlled conditions. Measurements in the 4.3$\mu$ region are described and are discussed in relation to molecular energy distributions, theoretically calculated emissivities and flame radiation.

4380 RADIO WAVE ABSORPTION OF SEVERAL GASES IN THE 100 TO 117 kMc/s FREQUENCY RANGE.

C.O.Britt, C.W.Tolbert and A.W.Straiton.

J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 1, 15-18 (Jan.-Feb., 1961).

Describes a technique for the measurement of the absorption characteristics of millimetre radio waves over a wide pressure range and presents the results of measurements made with this technique for four gases in the frequency band from 100 to 117 Gc/s. The four gases investigated in near pure state were carbon monoxide, nitrous oxide, sulphur dioxide, and nitrogen dioxide.

# VACUUM PHYSICS

4381 RECENT RESULTS IN ULTRA-HIGH VACUUM. C.Kleint.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 5, 193-210 (1960). In German.

Recent literature on methods of obtaining and measuring ultra-high vacuum is reviewed followed by a discussion on the use of the field emission microscope for the observation of residual gases. Experiments are described in which the shot noise of field emission currents is interpreted as a criterion for cleanliness of the emitter and hence the degree of vacuum. The application of field-emission methods to work function studies is considered.

W.Steckelmacher

4382 RECENT ADVANCES IN ULTRA-HIGH VACUUM TECHNOLOGY. D.Alpert.
Vacuum (GB), Vol. 9, 89-96 (May, 1959; publ. Dec., 1960).

The two major directions for advances in ultra-high vacuum technology are (1) the attainment and measurement of pressures below $10^{-10}$ mm Hg, and (2) the development of large ultra-high vacuum systems. New vacuum components have recently been introduced which are of great value in both of these directions. Of particular interest are the development of ionization gauges capable of reading pressures below $10^{-12}$ mm Hg and the design of systems several orders of magnitude larger than those heretofore described. Contributions of a number of workers in this field are briefly discussed. One of the most important recent developments is the "getter-ion" pump as a means of achieving both lower pressures and high pumping speeds. It has been shown that very simple "getter-ion" pumps are possible which can replace diffusion pumps to achieve pressures down to the $10^{-10}$ mm Hg region. Despite this achievement there are many unanswered questions involving the underlying mechanisms of sorption and desorption for neutral and activated molecular gases. Preliminary experiments have been made on the sticking probability of certain gases on titanium and the effect of an adjacent ionizing electron beam.

4383 ON THE CHOICE OF UNITS OF PRESSURE AND OF FLOW IN VACUUM TECHNIQUE.
E.Thomas, R.Servranckx and R.Leyniers.
Vacuum (GB), Vol. 9, No. 3-4, 207-8 (July-Sept., 1959; publ. Dec., 1960).

The various units of pressure and flow used in vacuum technique are examined. The use of a more adequate unit of pressure, related in a simple way to existing units, is proposed.

4384 A HIGH-CAPACITY VACUUM ADSORPTION PUMP. B.G.Lazarev and M.F.Fedorova.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 865-7 (July, 1960). In Russian.
For abstract, see Abstr. 16741 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 7, 815-17 (Jan., 1961)].

4385 EVAPOR-ION PUMP DEVELOPMENT AT THE UNIVERSITY OF WISCONSIN. R.G.Herb.
Vacuum (GB), Vol. 9, 97-107 (May, 1959; publ. Dec., 1960).

Evapor-ion pumps have been developed at the University of Wisconsin for a variety of applications. The largest of these pumps has a diameter fo 24 in. It is used in connection with a hydrogen negative ion source and gives a pumping speed for hydrogen of approximately 15 000 l./sec at pressures in the region of $5 \times 10^{-6}$ mm Hg. Several pumps of 12 in. diam. and of 8 in. diam. are now being used. For other applications pumps of 1 in. diam. and 2 in. diam. were developed. Evaporation techniques, starting techniques, and general operational characteristics of these pumps are given.

4386 HOT-CATHODE MAGNETRON IONIZATION GAUGE FOR THE MEASUREMENT OF ULTRA HIGH VACUA. J.M.Lafferty.
J. appl. Phys. (USA), Vol. 32, No. 3, 424-34 (March, 1961).

In order to extend the low-pressure limit of the conventional hot-cathode ionization gauge it is necessary, at a given emission current, to increase the ratio of the ion current to the X-ray photocurrent. This ratio may be increased by increasing the sensitivity of the ionization gauge. The gauge may be modified to permit the electrons to travel in long paths before they are collected by the positive grid or anode. Under these conditions the probability of the electrons' colliding with and ionizing a gas molecule will be enhanced, and the sensitivity of the gauge will be improved with no increase in X-ray photoemission. To accomplish this a magnetron with a cylindrical anode was selected for the ionization gauge and operated in a magnetic field with an intensity of 2.5 times the cutoff value. Two end plates maintained at a negative potential relative to the cathode collect the ion current generated in the magnetron and prevent the escape of electrons. Positive ion emission from the cathode is suppressed by mounting a hairpin filament on the axis of the cylindrical anode and well removed from the region of the negative ion collector. A very low level of electron emission is used to prevent instabilities in operation and to give a maximum ratio of ion current to X-ray photocurrent. Measurements of sensitivity and X-ray photocurrent indicate that the magnetron gauge is linear down to a pressure of $4 \times 10^{-14}$ mm Hg. Ability to measure low pressures with the gauge appears to be limited by the sensitivity of the circuit measuring the low ion currents. The ion pumping speed was found to be 0.003 l./sec under normal operating conditions. Magnetron gauges have been built with ceramic metal envelopes.

4387 IONIZATION GAUGE HEAD FOR VERY HIGH VACUUM MEASUREMENTS. S.Pytkowski.
Przeglad Elektron. (Poland), Vol. 1, No. 1, 87-9 (1960). In Polish.

The construction of a Bayard—Alpert-type ionization gauge head and its theory are given. J.M.Zarzycki

4388 THE MEASUREMENT OF THE PRESSURES OF VARIOUS GASES BY MEANS OF A PIRANI GAUGE. S.Veis.
Vacuum (GB), Vol. 9, No. 3-4, 186-9 (July-Sept., 1959; publ. 1960).

The relation between the pressure and the potential difference existing across the diagonal of the Wheatstone bridge, which is a function of pressure, is determined for a Pirani gauge. Using this relation, calibration curves for various gases may be calculated from Pirani gauge calibration curves for a given gas.

4389 A McLEOD MANOMETER WITH PRESCRIBED VOLUMES FOR USE AS A STANDARD INSTRUMENT. C.G.J.Jansen and A.Venema.
Vacuum (GB), Vol. 9, No. 3-4, 219-30 (July.-Sept., 1959; publ. 1960).

The McLeod manometer is one of the few instruments with which it is possible to measure the actual values of low gas pressures ($5\text{-}10^{-5}$ mm Hg) without changing the composition of the gas. The McLeod gauge is therefore indispensable for calibrating the faster indicating instruments which only register relative pressure units, e.g. ionization gauges, heat-conductivity manometers, etc. Since it is very cumbersome to make and calibrate a McLeod gauge that can be used as a standard, it is worthwhile to improve the construction in such a way that a calibration can be omitted. In connection with this problem a critical study was made of the formulae used to calculate the gas pressure from the readings of the McLeod manometer, which lead to expressions for the relative systematic and accidental errors limiting the measuring accuracy. By using a very accurate set of jigs in making the capillaries and the transition volumes at the connection between capillaries of different diameters and by addition of a small correction volume to the compression bulb it was possible to construct a McLeod gauge indicating the actual gas pressures in the range of $3.5\text{-}10^{-5}$ mm Hg on one convenient set of scales. The volume of the compression bulb and the volume and diameters of the capillaries were calculated in such a way that full centimetres on the various scales correspond to $10^{-3}$, $10^{-2}$ and $10^{-1}$mm Hg respectively. The zero lines of the different sub-ranges of the instrument lie at whole centimetres from each other and at multiples of half-centimetres from the top of the compression capillary.

4390 STUDIES ON A SPECTROMETRIC LEAK DETECTOR. J.Kalmer and W.Górski.
Przeglad Elektron, (Poland), Vol. 1, No. 1, 77-9 (1960). In Polish.

Gives a brief description of a leak detector using a helium mass spectrometer and detecting leaks of the order of $10^{-8}$ torr l./sec under favourable conditions. J.M.Zarzycki

4391 USE OF AN ION PUMP AS A LEAK DETECTOR. J.R.Young.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 85 (Jan., 1961).

A cold-cathode gas discharge ion pump has been used as a leak detector and found to operate satisfactorily. Argon, helium, oxygen, and hydrogen were used effectively as probe gases, with argon usually giving the greatest response. Leaks from $10^{-3}$ to $10^{-8}$ std cc/sec could be located in a few minutes and leaks as small as $10^{-10}$ std cc/sec or $10^{-7}$ μlitre/sec could be detected.

4392 A GENERAL PURPOSE HALIDE LEAK DETECTOR FOR TESTING VACUUM AND OVERPRESSURE EQUIPMENT. B.Wienecke.
Technik (Germany), Vol. 15, No. 12, 809-13 (Dec., 1960). In German.

The sensing element was a conventional platinum diode giving rise to changes in positive ion emission in the presence of a halide. In the overpressure method the element was mounted in a hand-held probe containing a small turbine pump to allow continuous sampling of the air. The performance was improved by incorporating a jet system at the probe tip for shielding the pickup point by an adjustable stream of clean air. For vacuum testing, the detector consisted of a diode element mounted in a glass tube for connecting into the vacuum system. Ion current changes were measured on a meter after d.c. amplification and also converted to an audible signal. The construction of calibrated reference leaks is described. With atmospheric pressure differentials leaks of the order $10^{-6}$ torr l./sec were detected in the overpressure method while leaks of $2 \times 10^{-7}$ torr l./sec were detectable in the case of the vacuum method. W.Steckelmacher

4393 TESTING OF VACUUM EQUIPMENT AND HERMETICALLY SEALED COMPONENTS FOR LEAK TIGHTNESS. W.Steckelmacher.
Schweiz. Arch. angew. Wiss. Tech. (Switzerland), Vol. 27, No. 2, 79-88 (Feb., 1961).

Various methods of leak detection are described which are applicable to the testing of vacuum plant or hermetically sealed containers suitable for gases, liquids, etc. The measurement of leakage rates as well as difficulties arising in the exact location of leaks are discussed. Overpressure and vacuum methods are considered separately and different test procedures are described. The operation of detectors based on the hot wire snifter, halide diode, infrared gas analyser, mass spectrometer and ionization gauges is explained. The use of $H_2$, He, A halides, $CO_2$, $N_2O$ and radioactive isotopes as search gases are mentioned. The methods are summarized in a table listing their pressure ranges, sensitivity and application.

4394 VACUUM FLOWMETER. M.I.Basalaev and N.Ya.Basalaeva.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 75-8 (March-April). In Russian.

An instrument for measuring gas flow is described, designed for application in vacuum technology. The principle of the instrument is based on measuring the pressure drop across a diaphragm through which the flow is passing. The pressure drop is measured by a bridge circuit, two branches of which are two identical resistance manometers located on either side of the diaphragm. [English translation in: Instrum. exper. Tech. (USA), No. 2, 260-4 (March-April, 1958; publ. April, 1959)].

4395 PUMPING OF TUBES ON A DOUBLE PUMPING UNIT. R.Rocherolles.
Vide (France), Vol. 15, 112-19 (March-April, 1960). In French and English.

The processing of metal vacuum-tubes pumped by a glass mercury diffusion pump and two liquid-air traps in series is described. The tubes were surrounded by a bell jar evacuated by a second oil-diffusion pumped vacuum system. The bell jar contained molybdenum heating elements surrounded by nickel radiation screens allowing the tube to be heated up to 1000°C. After 24 hours stoving at 600°C at the tube and 450°C at one liquid-air trap, a pressure of $4 \times 10^{-9}$ torr was obtained. This pressure was reduced to $3 \times 10^{-10}$ torr on filling the second liquid-air trap. W.Steckelmacher

VACUUM TECHNIQUES AND COMPONENTS USED FOR A CONTINUOUSLY PUMPED LINEAR ELECTRON ACCELERATOR. See Abstr. 4676

THE ULTRA-HIGH-VACUUM SYSTEM FOR THE C-STELLARATOR. See Abstr. 4619

SMALL HIGH-TEMPERATURE VACUUM FURNACE. See Abstr. 4507

# VIBRATIONS . ELASTIC WAVES

*(See also Shock Waves)*

4396 FLEXURAL VIBRATIONS OF A CIRCULAR CENTRALLY-LOADED ELASTIC PLATE. V.V.Tyutekin.
Akust. Zh. (USSR), Vol. 6, No. 3, 388-91 (1960). In Russian.

Discusses the fundamental frequencies of axisymmetric flexural vibrations of a circular elastic plate loaded with an arbitrary impedance at the centre. The characteristic equation is deduced and its solution is given for an inertial load. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 389-92 (Jan.-March, 1961)]. A.Tybulewicz

4397 MEASUREMENTS ON DAMPING MATERIALS SPRAYED ON STEEL TUBES. C.Bordone-Sacerdote.
Acustica (Internat), Vol. 9, No. 2, 75-8 (1959).

Theoretical expressions are derived for the resonant frequency of a tube vibrating longitudinally when its outer surface is completely or partially coated with a damping material. Experiments are described using a steel tube 90 cm long, 2.4 cm in diameter and 0.1 cm wall thickness having a natural frequency of about 2800 c/s when uncoated; curves are given of the resonant frequency, decrement and loss factor for the tube coated with various thicknesses of bituminous or plastic material. H.J.H.Starks

4398 INTERACTION OF PLANE LONGITUDINAL AND TRANSVERSE ELASTIC WAVES. Z.A.Gol'dberg.
Akust. Zh. (USSR), Vol. 6, No. 3, 307-10 (1960). In Russian.

An infinite isotropic solid is investigated, using equations of motion which include terms with squares of the derivatives with respect to the deformation vector. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 306-10 (Jan.-March, 1961)] A.Tybulewicz

4399 REFLEXION AND REFRACTION OF PLANE ELASTIC WAVES AT A PLANE BOUNDARY BETWEEN AEOLOTROPIC MEDIA. M.J.P.Musgrave.
Geophys. J. (GB), Vol. 3, No. 4, 406-18 (Dec., 1960).

General equations in stress and displacement are set down and their implications qualitatively discussed. Detailed results are presented for the slownesses, amplitudes and energy fluxes of body waves generated by the incidence of a body wave upon a range of differently oriented boundaries in hexagonal media. Results for ice and beryl show that the assumption of isotropy preserves the qualitative form of the reflection characteristics; in contrast, the variations caused by changing the orientation of the boundary in zinc are too great to be adequately represented in terms of isotropic constants.

4400 SURFACE ELASTIC WAVES IN SEMICONDUCTORS. D.C.Gazis, R.Herman and R.F.Wallis.
J.Phys. Chem. Solids (GB), Vol. 14, 268-70 (July, 1960).

The elasticity factors ($c_{11}$, $c_{12}$ and $c_{44}$) determining the type of wave that occurs on the (001) surface of a cubic crystal are discussed and some results are quoted for diamond, Si, Ge and PbS. Curves of the phase velocity ratio for these materials and of the attenuation constants for Si are also given as a function of the angle between the direction of propagation and the (100) axis. H.J.H.Starks

# ACOUSTICS

4401 NON-LINEAR EFFECTS IN SOME ACOUSTIC PROBLEMS. M.A.Isakovich.
Akust. Zh. (USSR), Vol. 6, No. 3, 321-5 (1960). In Russian.

Discusses non-linear effects (quadratic corrections) in the Sturm—Liouville problem and in the problem of propagation in a waveguide. Shows that, in contrast to propagation in an infinite space, the secular terms are absent in the solutions, with the exception of degenerate cases. This absence of secular terms is due to dispersion. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 321-5 (Jan.-March, 1961)]. A.Tybulewicz

4402 CALCULATION OF ACOUSTIC RADIATION EMITTED BY A TURBULENT AERODYNAMIC STREAM.
L.M.Lyamshev.
Akust. Zh. (USSR), Vol. 6, No. 4, 472-7 (1960). In Russian.

Lighthill's equations (Abstr. 3372 of 1952; 3188 of 1954) are used to calculate the acoustic radiation from a turbulent stream in free space and in the presence of elastic surfaces outside the stream. The wavelength dependence of the generated sound is dealt with. [English translation in: Soviet Physics—Acoustics (USA)].
A.Tybulewicz

4403 THE OPTIMUM WORKING CONDITIONS FOR A POWERFUL [ACOUSTIC] CONCENTRATOR.
K.A.Naugol'nykh and L.D.Rozenberg.
Akust. Zh. (USSR), Vol. 6, No. 3, 352-5 (1960). In Russian.

Discusses a spherical focusing system when the intensity of the focused sound is high and nonlinear distortions of the waveform are important. Conditions needed to obtain maximum amplitude of the wave velocity at the focus are derived. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 352-5 (Jan.-March, 1961)].
A.Tybulewicz

4404 BALANCE OF ENERGY IN A CONCENTRATOR DESIGNED TO SUPPLY ULTRASOUND OF HIGH INTENSITY. M.G.Sirotyuk.
Akust. Zh. (USSR), Vol. 6, No. 3, 410-11 (1960). In Russian.

A hemispherical ultrasonic concentrator (511 kc/s) consisting of a quartz mosaic coupled by oil to a half-wavelength aluminium plate radiating into water gives a measured value of 2780 W with 4 kV across the mosaic. This is within 5% of the value calculated from Q measurements under four different conditions (with and without oil and water). [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 409-11 (Jan.-March, 1961)].
V.J.Hammond

4405 PROPAGATION OF [ACOUSTIC] WAVES IN A NON-UNIFORM WAVEGUIDE.
L.M.Brekhovskikh and V.A.Eliseevnin.
Akust. Zh. (USSR), Vol. 6, No. 3, 284-91 (1960). In Russian.

A waveguide is considered whose properties vary along the propagation path. For a special case, the problem of propagation is solved both exactly and using the ray approximation. The present theory can be used in the analysis of long-distance propagation of acoustic and electromagnetic waves in natural waveguides. Possible generalizations of the results are indicated. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 282-90 (Jan.-March, 1961)].
A.Tybulewicz

4406 AN EXAMPLE OF ANTIWAVEGUIDE PROPAGATION OF SOUND IN LAMINAR-INHOMOGENEOUS MEDIA.
E.P.Masterov and V.N.Muromtseva.
Akust. Zh. (USSR), Vol. 6, No. 3, 335-9 (1960). In Russian.

The following assumptions are made: (1) the square of the index of refraction increases with height according to a square law; (2) the boundary is perfectly reflecting and is located in the horizontal plane where the index of refraction is a minimum. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 335-9 (Jan.-March, 1961)].

4407 PROPAGATION OF FINITE-AMPLITUDE [SOUND] WAVES IN RELAXING MEDIA. A.L.Polyakova.
Akust. Zh. (USSR), Vol. 6, No. 3, 356-9 (1960). In Russian.

The propagation is considered in the second approximation, and it is shown that if $\rho_1/\rho_0 < 2\Delta c/c_0$, i.e., if the amplitude is less than a value which is characteristic of dispersion and relaxation absorption, then the behaviour of the second harmonic will be determined primarily by absorption. In this case, the effects due to phase shifts (as the result of dispersion) appear only at frequencies near $\omega\tau = 1/\sqrt{2}$, when the influence of dispersion reaches a maximum, and the influence of absorption a minimum. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 356-9 (Jan.-March, 1961)].

4408 SOUND WAVES IN DEFORMED PERFECTLY ELASTIC MATERIALS. ACOUSTOELECTRIC EFFECT.
R.A.Toupin and B.Bernstein.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 216-25 (Feb., 1961).

The general equations for a small displacement superimposed on a finite deformation of a perfectly elastic material of arbitrary symmetry are derived anew. These equations are the basis of an analysis of plane waves of small amplitude propagating in an initially deformed and stressed elastic material. Certain restrictions on the energy function of finite elasticity theory are determined. These restrictions, which provide necessary and sufficient conditions that a homogeneously deformed material admit plane waves, are then compared with other restrictions obtained from thermostatic equilibrium considerations. Compatibility conditions, which are necessary and sufficient that data on sound wave propagation in elastic materials be compatible with classical elasticity theory upon suitable assignment of the material symmetry, are derived. Finally, it is shown how the variation of sound speeds with initial stress and the measured magnitude of the acoustoelastic effect can be used to determine the third-order elastic constants of an isotropic material and as a partial confirmation and experimental check to the theory.

4409 MEASUREMENT OF THE COEFFICIENT OF TRANSVERSE CORRELATION IN A CONTINUOUS SOUND SIGNAL IN THE SEA. S.G.Gershman and Yu.I.Tuzhilkin.
Akust. Zh. (USSR), Vol. 6, No. 3, 292-8 (1960). In Russian.

Reports measurements of the transverse correlation of a continuous noise signal of 7.5 ± 0.2 kc/s frequency (transverse correlation is taken to mean the mutual correlation between signals at various points of the same wave-front). At distances (r) of up to 12 km between the sound source and the wave-front and for separation of the receivers (d) up to 3 km the correlation coefficient was close to unity and independent of r and d. The authors also measured fluctuations of the coefficient of correlation between reflected and non-reflected signals. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 291-7 (Jan.-March, 1961)].
A.Tybulewicz

4410 COMPARISON OF A FAMILIAR FORMULA FOR SPEED OF SOUND IN SEA WATER WITH THE KUWAHARA-MACKENZIE FORMULA. F.E.Bellas.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 249 (Feb., 1961).

Mackenzie has given a new formula for the speed of sound in seawater (see Abstr. 989 of 1960). This letter compares the new formula with a more familar formula, since the new one contains more terms and conveys the impression of being a much better approximation.

4411 THEORY OF ULTRASONIC ATTENUATION IN CYLINDRICAL AND RECTANGULAR WAVEGUIDES.
E.F.Carome and J.M.Witting.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 187-97 (Feb., 1961).

A theoretical study is made of attenuation of ultrasound in cylindrical and rectangular waveguides. The systems treated consist of a piston source radiating into a bounded, inviscid fluid and a receiver of the same size as the source. Expressions for receiver output are derived, and acoustic loss as a function of path length is computed for various source and waveguide configurations. Boundary conditions corresponding to both perfectly rigid and perfectly free walls are considered. The waveguide approach is extended to the limiting case of radiation into an unbounded medium, and results are given for both square and circular systems. In the latter case the curve of loss versus path length agrees well with that previously obtained using more conventional diffraction theory.

4412 REFLECTION OF WAVES OF FINITE AMPLITUDE. Fén Shao-sun [Fêng Shao-sung].
Akust. Zh. (USSR), Vol. 6, No. 4, 491-3 (1960). In Russian.

The waves are incident on a wall at an angle of $\pi/4$. The results obtained by successive approximations (including the second approximation) show that a wave with double the original frequency appears and its amplitude increases with distance (this wave is reflected according to linear acoustic laws). A second wave of doubled frequency appears as well; its amplitude does not increase with distance and it has cylindrical symmetry. [English translation in: Soviet Physics—Acoustics (USA)].
A.Tybulewicz

REFRACTION AND DIFFRACTION OF PULSES.
See Abstr. 4721

4413 SCATTERING OF ACOUSTIC ENERGY BY SOLID AND AIR-FILLED CYLINDERS IN WATER.
G.R.Barnard and C.M.McKinney.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 226-38 (Feb., 1961).

This paper presents the results of an experimental investigation of the scattering of acoustic energy from finite circular cylinders in water. Photographs are shown of the pulses scattered in the backward direction in the plane normal to the longitudinal axis and in the plane containing the longitudinal axis of a cylinder. The echo

structure exhibits characteristics dependent upon the corners of the cylinder where there is a sharp change in the slope of the projected area and discontinuities between air, brass, and water. The photographs of pulses returned from the cylinders in the plane normal to the longitudinal axes imply the existence of surface waves which travel around the circumferences of the cylinders. Distribution-in-angle diagrams of acoustic energy scattered in the plane perpendicular to the longitudinal axes of solid and hollow air-filled cylinders were taken for changes in cylinder length, changes in pulse length, and changes in acoustic radii. Length modes of vibration do not affect significantly the energy scattered perpendicular to the longitudinal axis. When pulses, which are long compared to the diameter of the cylinder, are used, the scattered energy distribution is depedent upon the composition and the acoustic radius of the cylinder.

4414 A THEORY OF ACOUSTIC STREAMING NEAR HOT SOLIDS. P.N.Kubanskii.
Akust. Zh. (USSR), Vol. 6, No. 4, 462-7 (1960). In Russian.

Gives a modified system of equations for acoustic streaming distorted by convection. Simplifying assumptions are justified and formulae are deduced for the distribution of streaming velocities and temperatures near a hot solid in a strong acoustic field. The heat transfer coefficient is calculated. The principle of superposition is shown to be applicable to acoustic streaming and convective flow at medium acoustic intensities. [English translation in: Soviet Physics—Acoustics (USA)]. A.Tybulewicz

4415 NARROW-BEAM ECHO-RANGER FOR FISHERY AND GEOLOGICAL INVESTIGATIONS.
M.J.Tucker and A.R.Stubbs.
Brit. J. appl. Phys., Vol. 12, No. 3, 103-10 (March, 1961).

A 36 kc/s underwater acoustic echo-ranger, fitted to R.R.S. "Discovery II" for work on fish detection problems, has also proved to be a valuable tool for marine geological investigations. The axis of the acoustic beam is perpendicular to the fore and aft line of the ship and may be rotated from the horizontal to the downward vertical. Stabilization is provided against the roll of the ship. Beam width and side lobe patterns are adjustable with minimum widths, between 3 dB points, of 1.3° in plan and 12° in elevation (beam axis horizontal). The recorder provides a range of 800 yards and scanning is achieved by steaming the ship past the features to be investigated.

4416 ACOUSTICO–OPTICAL PICTURE TRANSFORMATION BY MEANS OF PHOTOGRAPHIC FILMS. G.Keck.
Acustica (Internat.), Vol. 9, No. 2, 79-85 (1959). In German.

A review and discussion of the methods by which ultrasonic shadows and focused beams can be reproduced on photosensitive films. The methods depend on the rate of chemical reaction at the irradiated and shaded parts of the films. Good results are obtained using a dilute developer. Colour films can be turned into ultrasonic images. Examples using both perpendicular and parallel ultrasonic radiation on the films are described. S.Weintroub

EFFECT OF ULTRASONIC OSCILLATIONS ON THE DIFFUSION OF AN ELECTROLYTE IN A GELATIN GEL. See Abstr. 4106

# Instruments and Measurements

4417 PRESSURE RESPONSE OF CONDENSER MICROPHONES AT LOW AMBIENT PRESSURES.
J.D.Chalupnik, E.Rule and F.J.Suellentrop.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 177-8 (Feb., 1961).

The frequency response characteristics of condenser microphones at low ambient pressures are of interest when such microphones are used to make measurements on high-altitude rockets and capsules. Pressure response curves at a number of ambient pressures in the range $10^6$ dyn/cm$^2$ (atmospheric pressure at sea level) to $1.7 \times 10^4$ dyn/cm$^2$ (atmospheric pressure at 90 000 ft) have been obtained for two commonly used condenser microphones (Western Electric 640AA, Bruel and Kjaer type 4111). Features of the response curves are discussed from a qualitative point of view.

4418 PULSED SYSTEM FOR MEASURING THE VELOCITY OF ULTRASONIC WAVES.
F.F.Voronov, L.F.Vereshchagin and V.I.Murav'ev.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 81-5 (May-June). In Russian.

The system determines the velocity by measuring precisely the delay of an echo (using a delayed sweep on an oscilloscope). The calibration of the delay time can be checked against a quartz-crystal oscillator. [English translation in: Instrum. exper. Tech. (USA), No. 3, 410-14 (May-June, 1958; publ. June, 1959)].

4419 A STUDY OF THE REVERBERATION CHAMBER IN THE DEPARTMENT OF ACOUSTICS OF MOSCOW STATE UNIVERSITY. I.V.Lebedeva.
Akust. Zh. (USSR), Vol. 6, No. 3, 326-34 (1960). In Russian.

Describes a detailed study of the properties of the chamber. Gives characteristics of sound propagation and field uniformity as well as the correlation coefficient between acoustic pressures at two different points. The reverberation time in the empty chamber was 19 sec at 160 c/s and fell to 2.9 sec at 5000 c/s. Conditions are given for the establishment of a diffuse acoustic field, satisfying requirements for measurements of the statistical sound absorption ciefficient. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 326-34 (Jan.-March, (1961)]. A.Tybulewicz

4420 THE UPPER LIMITS FOR THE REVERBERATION TIME OF REVERBERATION CHAMBERS FOR ACOUSTIC AND ELECTROMAGNETIC WAVES. K.Walther.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 127-36 (Feb., 1961).

The upper limits for the reverberation time and Q factor of acoustic reverberation chambers with perfectly rigid walls with a smooth surface are determined. The reflection factor for a rigid wall of arbitrary thermal conductivity is determined from a consideration of the viscosity and heat conductivity boundary layer. The cases of isothermal and adiabatic boundary conditions are discussed. At very low frequencies the boundary absorption and at very high frequencies the volume absorption are the important factors in determining the losses. The analogous problem of the electric reverberation chamber is compared with the acoustic case. For some conditions the electric and acoustic equations are identical in form, if the electric skin depth is replaced by the thickness of the acoustic viscosity boundary layer. At comparable wavelengths and room sizes the electric Q factors are approximately a factor of 50 higher than the acoustic upper limiting values.

# Noise . Architectural Acoustics

4421 THE MEANING AND MEASUREMENT OF PERCEIVED NOISE LEVEL. K.D.Kryter.
Noise Control (USA), Vol. 6, No. 5, 12-27 (Sept.-Oct., 1960).

The well-known pure tone equal-loudness contours have generally been used in the past when estimating the subjective effects of complex sounds. It is proposed that the contours are modified so as to give the "perceived noise level" (PN dB) of complex sounds. Copeland, Robinson et al. have shown by tests on 1600 observers that modern aircraft noises may be rated differently for noisiness (disturbance or annoyance) as distinct from loudness. Related work by Stevens, Zwicker, Cremer and others is mentioned, and curves, tables etc., used by the author for the computation of perceived noise levels are given. The term "noys" is applied to the proposed new unit. The contours give more weight to high frequencies and the 1 noy contour approximates to the + 40 dB pressure level at 1 kc/s, a doubling of the noys figure approximating to a 10 dB increase, as with the sone scale. The possibility is discussed of using a sound level meter with an "N" weighting network, this being similar to the "B" network but with a lift of about 15 dB at 5 kc/s. An up-to-date bibliography is given, including a reference to the author's earlier work (Abstr. 813 of 1960). M.L.Gayford

4422 RESEARCH ON NOISE MEASUREMENT. E.Lübcke.
Nachrichtentech. Fachber (NTF) (Germany), Vol. 15, 12-16 (1959). In German.

References made to an earlier paper on the technique of noise measurement [V.D.I. Berichte (1958)]. In the present paper, noise measurements are made with $\frac{1}{3}$ octave, $\frac{1}{2}$ octave and 1 octave bandwidths over a range of frequencies extending from 25 c/s to 10 kc/s, using different types of ground-level meters. The sources

of noise used in the investigation include: (a) lathe; (b) air-noise; engine room of a ship; and (c) ship's cabin etc. The differences (usually small) arising in the various methods of measurement are discussed. A.B.Wood

# OPTICS . PHOTOMETRY

4423 AN ASPECT OF INFORMATION THEORY IN OPTICS. H.Gamo.
IRE internat. Convention Record (USA), Vol. 8, Pt 4, 189-203 (1960).

Coherent, partially coherent and incoherent illumination are characteristic conditions upon which the nature of optical images is dependent. Under these conditions, by use of the response function, sampling theorem and intensity matrix for optical images, the limit of resolution of neighbouring objects is shown to be the same. The amplitude and phase information derived from images of an object is determined by the degree of coherence of illumination and the noise in intensity measurements. This is shown by use of experimentally obtained elements of an intensity matrix for images.

4424 THE CRITICAL VELOCITY FOR EMISSION OF LIGHT IN OPTICALLY ANISOTROPIC MEDIA. I.M.Frank.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1751-7 (June, 1960). In Russian.

Considers emission of light with an arbitrary natural frequency by a source moving uniformly in an anisotropic medium. Deals with the special cases of Cherenkov radiation and complex Doppler effect. Discusses the phase, ray and group velocities of light. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1263-7 (Dec., 1960)].

4425 PHOTOMECHANICAL EFFECTS. E.Lau and E.Gehrmann.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 354-7. In German.

The silver grains in a photographic film, clamped on one side, cause a movement of the free edge of the film when the assembly is irradiated with light in the visible and near infrared. The effect is detected by an interference microscope and will follow an alternating light source up to $10^4$ c/s. The sensitivity of such assemblies compares with that of thermopiles and similar detectors of radiation. C.A.Hogarth

4426 AN ADVANCE IN METHODS OF PHOTOMETRY OF STRUCTURED MICROSCOPIC PREPARATIONS. G.Exner.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 255-8. In German.

Microphotometry in the u.v. region can give information about the cell structure and cell quantity in many biological specimens. A new scanning system is described and its applications briefly outlined. R.W.Fish

4427 HETEROCHROMATIC PHOTOMETRY. J.Terrien.
Bull. Soc. Franc. Elect. (Ser. 8), Vol. 1, No. 10, 655-62 (Oct., 1960). In French.

The various methods commonly used in heterochromatic photometry are outlined and it is mentioned that experiments are in progress at the Bureau International des Poids et Mesures on a method based on the determination of the ratio, wavelength by wavelength, of the energy outputs of the two sources being compared. The discussion contains much additional information regarding methods employed by different workers. J.W.T.Walsh

4428 DOUBLE-BEAM INTERMITTENT PHOTOMETER SYSTEM USING A VIBRATING OSCILLOGRAPH MIRROR. H.Mütze.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 5, 224-8 (1960). In German.

The mirror was oscillated so as to direct light into a photocell alternately from the measuring and the comparison beams, giving a compact arrangement with low noise, freedom from mechanical disturbance and the possibility of using very high alternating frequency for the mirror with efficient electrical filters of narrow band-width. The system was used in a recording microphotometer and a trace of the Hg blue line is given, showing isotopic fine structure. W.T.Welford

4429 ABSOLUTE CALIBRATION OF A LIGHT DETECTOR. R.L.Christensen and I.Ames.
J. Opt. Soc. Amer., Vol. 51, No. 2, 224-36 (Feb., 1961).

A method is described for the determination of the absolute spectral sensitivity of a photomultiplier in the wavelength range from 2200A to cutoff. The standard of radiation is thermal radiation from a tungsten strip lamp and the dispersing instrument is an arrangement of two conventional grating monochromators in tandem. The major portions of the calibration are the determinations of the monochromator transmissions and then of the relative and finally absolute spectral sensitivity of the photomultiplier. As an example of the use of this detector, the determination of the absolute spectral output of two lamps is described.

4430 DISTRIBUTION OF FLUORESCENCE FROM A DISK-SHAPED CUVETTE. W.H.Melhuish.
J. Opt. Soc. Amer., Vol. 51, No. 3, 278-9 (March, 1961).

Errors due to internal reflection in cuvettes used for absolute fluorescence measurements were investigated. The angular distribution of fluorescence and the flux along the normal from a disk-shaped cuvette were measured. The distribution of fluorescence from the cuvette with blackened back and sides was close to the expected distribution and the flux along the normal increased by only 5% at 4 cm distance, as against 20% for the unpainted cuvette.

4431 AUTOMATIC PHOTOMETER FOR MEASURING THE ANGULAR DISSYMMETRY OF LIGHT SCATTERING. F.J.Baum and F.W.Billmeyer, Jr.
J. Opt. Soc. Amer., Vol. 51, No. 4, 452-6 (April, 1961).

A photometer is described for the automatic measurement and recording of the dissymmetry of light scattering in the angular range 20-160°. The instrument is primarily designed for the measurement of the molecular weight and associated parameters of high polymers. A high degree of freedom from stray light and an unusually favourably optical geometry are achieved by employing a unique optical system and a cylindrical scattering cell of new design. Adequate sensitivity, accuracy, and stability are demonstrated, together with ease and flexibility of operation up to temperatures of 150°C. Scattered light intensity as a function of angle is both recorded and punched onto paper tape for subsequent processing in a digital computer.

# GEOMETRICAL AND INSTRUMENTAL OPTICS SPECTROSCOPY

*(Optical spectra and their analysis are included under the appropriate heading, e.g. Atoms, Molecules, Solid-State Physics, etc.)*

REFRACTION AND DIFFRACTION OF PULSES.
See Abstr. 4721

4432 HIGHER-ORDER IMAGERY. M.Herzberger.
J. Opt. Soc. Amer., Vol. 51, No. 2, 135-42 (Feb., 1961).

A mathematical procedure is described for transforming optical functions from one set of variables to another, irrespective of the order to which the functions are developed. The procedure is explained, and several problems to which it can be applied are outlined.

4433 IMAGING OF EXTENDED POLYCHROMATIC SOURCES AND GENERALIZED TRANSFER FUNCTIONS. G.B.Parrent, Jr.
J. Opt. Soc. Amer., Vol. 51, No. 2, 143-51 (Feb., 1961).

The problem of imaging with partially coherent polychromatic illumination is solved in terms of the most general formulation of coherence theory due to Wolf. It is shown that for this problem the frequency domain analysis is still valid and depends for its applicability only on the linearity and stationarity of the system being studied. The appropriate transfer function is seen to be the product of the frequency dependent aperture distribution considered as a function of spatial frequency $\mu_1$ multiplying its complex conjugate

evaluated at another frequency $\mu_2$. In previous work (see Abstr. 8394 of 1959, 19352 of 1960) several theorems relating to the existence and propagation of partially coherent fields were obtained. In the present paper these theorems are used to deduce the limiting forms of the generalized transfer functions referred to above. In particular the form of the transfer function for coherent and incoherent radiation is obtained with no approximation on the spectral width of the radiation. Further it is shown that introducing the quasi-monochromatic approximation reduces the generalized transfer functions to the familiar forms found in the literature.

4434 RADIATION, MOISTURE, AND TEMPERATURE EFFECTS IN FILLED EPOXY REPLICA FLAT MIRRORS. D.E.Kline and J.H.Saxton.
J. Opt. Soc. Amer., Vol. 51, No. 4, 447-51 (April, 1961).

The effects of nuclear radiation, moisture absorption, and temperature history on replica flat mirrors of filled epoxy were investigated using the optical flat testing method. A radiation dose of the order of $10^{10}$ ergs per gram is required to produce changes in surface flatness. Residual activity after neutron irradiation is found to be somewhat less than that of Pyrex glass. Absorption of a fractional percent of water causes a loss of flatness, but flatness can be restored by removing the moisture with elevated temperature baking. Flats appear to survive temperature cycling from −200 to +125° C with little detectable changes. Upon being subjected to temperatures above 140° C, the flatness decreases and the reflecting surface deteriorates rapidly.

4435 SPECTACLE LENSES WITH A REFRACTIVE POWER GRADIENT. R.Riekher.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 163-73. In German.

The disabilities due to presbyopia and the disadvantages of bi- and polyfocal lenses are discussed. Aspherical lenses offer a means of eliminating discontinuities. These new designs suffer from astigmatism, which may, however, be possibly compensated.

R.A.Weale

4436 STUDIES OF THE [LIGHT] INTENSITY DISTRIBUTION IN IMAGES OF POINT OBJECTS AND GRATINGS OF DIFFERENT SPACINGS. G.Schmidt and W.Reichel.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 305-12. In German.

An F/2.8 80 mm objective was computed and constructed. The light distribution in the axial image of a point was computed according to geometrical optics and according to diffraction theory and the response functions were measured. Detailed results are presented graphically. W.T.Welford

4437 TOTAL ILLUMINATION IN A DIFFRACTION IMAGE CONTAINING SPHERICAL ABERRATION. R.Barakat.
J. Opt. Soc. Amer., Vol. 51, No. 2, 152-7 (Feb., 1961).

The total illumination (or encircled energy) in a diffraction image containing spherical aberration is studied for various amounts of third- and fifth-order aberration. The Zernike polynomials are used to represent spherical aberration. The evaluation of the total illumination was done numerically, using double Gauss quadrature points. Contour maps of the total illumination were constructed and compared with the aberration-free case examined previously by Wolf (Abstr. 1773 of 1951).

4438 DIFFRACTION IMAGES OF CIRCULAR SELF-RADIANT DISKS. L.Smith and H.Osterberg.
J. Opt. Soc. Amer., Vol. 51, No. 4, 412-14 (April, 1961).

The diffraction image formed by an Airy-type objective when the object is a circular, uniformly self-radiant disk is found to exhibit the phenomenon of a secondary Airy disk when the radius of the object is near 1.2 Airy units. The time-averaged irradiance in the diffraction image is presented for radii up to 4 Airy units. A separate expression for the irradiance at the geometrical radius in the image shows that as the object becomes very large the value of this irradiance approaches one-half that at the centre of the image.

4439 MEASUREMENT OF WAVE ABERRATIONS OF MICROSCOPE AND OTHER OBJECTIVES.
M.De and M.K.Sen Gupta.
J. Opt. Soc. Amer., Vol. 51, No. 2, 158-64 (Feb., 1961).

The basic theory behind the measurement of axial and off-axis aberrations of micro-objectives tested by a new micro-objective testing interferometer, based on an apparatus developed earlier by Kingslake, is described from the point of view of wave aberrations and the interference theory. Since the formation of optical image is principally guided by the wave shape of the transmitted light, an effort was made to correlate systematically the treatment given by Kingslake, who looked at the subject from geometric point of view, and those of Chalmers and Gardner and Bennett, who concentrated their attention on the measurement of axial optical-path differences. It is shown how the axial and off-axis wave-aberration curves for the objective can be determined from the measured fringe shift at the chosen focal plane. The method of analysing the different aberration components is also indicated, and an example added to show the actual curves in a particular case.

4440 FLAT-FIELD MICROSCOPE OBJECTIVE. C.G.Wynne.
J. sci. Instrum. (GB), Vol. 38, No. 3, 92-4 (March, 1961).

The heavy field curvature found in the usual type of microscope objective of numerical aperture 0.65 is shown to be amenable to correction without complication of the basic five-glass form of construction. The relevant aberration theory is discussed, and numerical data are given for an N.A. 0.65 objective of × 40 magnification with substantially flat image field.

4441 CLAIRAUT–MOSSOTTI [CEMENTED DOUBLET APLANAT] OBJECTIVES AND NEW GLASSES. C.Bergeron and G.Penciolelli.
Rev. Opt. (France), Vol. 39, No. 9, 399-401 (Sept., 1960). In French.

A table showing the ratio of powers to make cemented doublet aplanats for different pairs of values of n in the range 1.50(0.04)1.90 is given, assuming the right dispersions to be available. It is shown that the use of glasses with higher n gives small zonal errors for a given size objective; alternatively, the relative aperture or the scale of the whole objective can be increased for the same zonal errors.

W.T.Welford

4442 THE EFFECT OF MOUNTING ERRORS ON DISTORTION AND THE POSSIBILITY OF COMPENSATION. G.Würtz.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 200-8. In German.

A properly mounted lens should possess only radial distortion. In practice, asymmetrical distortions are present, and these are accompanied by tangential distortions. It is usually suggested that these might be treated as if they arose from a thin deviating prism. Measurements on two lenses are quoted to show that this theory is not always applicable. Compensation is therefore not always possible and calibration of the errors is necessary. R.W.Fish

4443 MEASUREMENT OF THE CONTRAST REDUCTION FACTOR AND COMPARISON WITH THE GEOMETRICAL CORRECTION. J.Schilling and H.Zöllner.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 299-303. In German.

An equipment for measuring contrast reduction is briefly described. Three objectives of widely different states of correction are tested by a resolving-power method and by contrast reduction. The results are in broad agreement with the measured aberrations of the lenses. R.W.Fish

4444 A REVIEW OF THE IMPORTANCE OF DIFFERENT METHODS OF TESTING OBJECTIVES IN INDUSTRY. K.Kühne.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 304. In German.

A very brief review of methods used at Carl Zeiss, Jena for testing photographic lenses. No practical details are given.

R.W.Fish

DISTORTION OF PHOTOGRAMMETRIC OBJECTIVES. See Abstr. 4488-9

THE PRACTICAL DETERMINATION OF THE PHOTOGRAMMETRIC DISTORTION OF ULTRA WIDE-ANGLE OBJECTIVES FOR FINITE CONJUGATES. See Abstr. 4489

4445 OPTICAL SYSTEM FOR LARGE TELESCOPES. S.Rosin.
J. Opt. Soc. Amer., Vol. 51, No. 3, 331-5 (March, 1961).

An optical system composed of a large primary mirror and a closely spaced two-element lens system in the convergent beam delivers a high-quality image over a flat field of appreciable size. The mirror is hyperboloidal in form.

4446 FLAT-FIELDED MAKSUTOV-CASSEGRAIN OPTICAL SYSTEMS. R.L.Waland.
J. Opt. Soc. Amer., Vol. 51, No. 3, 359-66 (March, 1961).

The aim of this paper is to investigate the construction of an optical system of spherical or figured spherical surfaces suitable for astronomical photography, which would form optical images of high quality of a sufficiently large and practically flat field. The systems described use a pierced primary concave and a secondary convex mirror, together with the smallest number of correcting lenses to cancel out the aberrations resulting from the use of spherical or nearly spherical mirrors. It is totally enclosed, and covers a field of just under 4 deg.

4447 QUANTITATIVE MEASUREMENTS OF SCHLIEREN IN GLASSES. K.Kühne.
"Optics of all wavelengths" Meeting, Jena, 1958 (See Abstr. 224 of 1961) p. 358-61. In German.

The method involves the measurement of the difference between the colour of the schlieren and the surroundings, this difference being a measure of the magnitude of the schlieren. The measurement is accomplished by a combination of the classical Töpler schlieren method with a Savart double plate. The arrangement of the apparatus and its working is described and some results obtained for a glass sample 18 cm long are given. H.G.Jerrard

4448 FRESNEL ZONE PLATE FOR OPTICAL IMAGE FORMATION USING EXTREME ULTRAVIOLET AND SOFT X RADIATION. A.V.Baez.
J. Opt. Soc. Amer., Vol. 51, No. 4, 405-12 (April, 1961).

A new type of Fresnel zone plate was constructed which can focus ultraviolet radiation of any wavelength down to the soft X-ray region. It consists of a set of thin circular gold bands made self-supporting by radial struts, leaving the transparent zones empty. Experimental tests at 6700, 4358, and 2537 A showed that the theoretical minimum angular resolution obeys the Rayleigh criterion, $\sin\theta_{min} = 1.22\lambda/D$. The diameter of the zone plate is D = 0.26 cm and contains 19 opaque zones, the narrowest of which measured about 20 $\mu$ across. The zone plate was better than the optimum pinhole in resolution by a factor of about 6 and in speed by a factor of 40. The zone plate produced pictures that compared favourably with those made with a lens of similar focal length and aperture. The lens was about 20 times faster than the zone plate at 4358 A, but at 1000 A the zone plate would have been far faster than the lens. Focusing tests are contemplated at 1000 A and at 100 A where lenses and mirrors, the conventional image-forming devices, may fail. The angular resolution at 2537 A was close to the theoretical value of $1.2 \times 10^{-4}$ rad and held over a field of at least $1.75 \times 10^{-2}$ rad, which is 2.0 times the angle subtended by the sun's disk at the earth. A zone-plate telescope, operating in the soft X-ray or extreme ultraviolet region, far above the earth's atmosphere in an orbiting satellite, now seems possible.

4449 PHOTOMICROGRAPHIC MICROSCOPE FOR BOTH MICRO AND MACRO APPLICATION.
G.F.Norris, F.H.Meiller, K.T.Bolen and L.R.Crisp.
J. Opt. Soc. Amer., Vol. 51, No. 4, 445-6 (April, 1961).

A simple instrument is described for microscopic and macroscopic photographic recording of tissue preparations. It admits preparations up to 4 × 4 in. and allows magnification up to about 2600 × by easy interchange of components. The instrument also serves as a precision enlarger of 8-35 mm transparencies to 8 × 10 in. images.

4450 THE SOLID IMAGE MICROSCOPE: AN INSTRUMENT GIVING INFORMATION IN DEPTH BY OPTICAL SCANNING. R.L.Gregory.
Research (GB), Vol. 13, No. 11, 422-7 (Nov., 1960).

Although the binocular microscope gives an image in relief, the small depth of focus of a high-power microscope limits the depth of field which may be viewed. By scanning the objective in depth in synchronism with a moving screen it is possible to achieve a "solid" image. A method of achieving this is described. The objective is moved by a moving coil vibrator, operating at 50 c/s, while the image falls on a rotating helical screen. Applications are briefly described. R.W.Fish

4451 VISUAL SIGNAL GENERATOR. D.H.Kelly.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 50-5 (Jan., 1961).

A device is described which generates sinusoidal waves of radiant power for use in visual experiments. The instrument covers a continuous range of frequencies from 2 to 75 c/s, modulation amplitudes from 0.001 to 1.0, and luminance levels from 0.01 to 1500 mL. Frequency, amplitude, and luminance controls are mutually independent. Both "equal-energy" white light and narrow-band chromatic stimuli are provided.

DEVELOPMENTS IN MOLECULAR SPECTROSCOPY IN THE U.S.S.R. See Abstr. 3534

4452 A METHOD FOR INVESTIGATING THE QUANTITATIVE ABSORPTION OF CRYSTAL POWDERS. G.Schultz.
Ann. Phys. (Germany), Vol. 6, No. 7-8, 345-54 (1960). In German.

The method is based on multiple reflections. The theory is discussed and the apparatus used is described. Given a knowledge of the density, quantity of powder and the refractive index, then the absorption can be derived. Two absorption cells are used containing the material. An important advantage is that the derivation of the absorption coefficient does not require a knowledge of the particle size, which is difficult to determine. It depends only on the amount of material in the cell. S.Tolansky

4453 OPTIMUM CONDITION FOR RECORDING OF SPECTRA. G.G.Petrash.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 95-100. In Russian.

The optimum conditions for determination of the optical density are discussed in terms of the slit width, systematic and accidental errors (the former are assumed to be small) and the scanning rate. The resolution of two closely spaced absorption lines of finite width is also discussed. A.Tybulewicz

4454 PHOTOELECTRIC MIXING AS A SPECTROSCOPIC TOOL. A.T.Forrester.
J. Opt. Soc. Amer., Vol. 51, No. 3, 253-9 (March, 1961).

Photoelectric mixing is at present an effect which can be displayed with great difficulty. When combined with optical masers (or lasers), it may provide the basis of relatively simple optical measurements using radio-frequency-like receivers. In these receivers the detector or mixer is a photocell or other photoelectric device. Two general receiver types are considered and termed, following r.f. terminology, low-level and super-heterodyne receivers. The low-level receiver offers the possibility of simple observations of the special shape of the laser output. The superheterodyne receiver offers the possibility of measurement of the shapes of ordinary spectral lines although good resolution will require long observation times. As an instrument for comparing two laser outputs the superheterodyne optical receiver is capable of such extraordinary sensitivity that two lasers may be compared out to physical separations of $10^6$ km.

4455 MEASUREMENT OF THE DEPOLARIZATION FACTOR OF RAMAN LINES. M.Schubert.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 4, 155-61 (1960). In German.

Expressions are developed relating the true depolarization factor and the factor observed with convergent radiation. There is a linear relationship between these quantities, the slope and intercept of the line being expressed in terms of the angular distribution of radiation. G.F.Lothian

4456 IMAGE-CONVERTER RECORDING OF SPARK-DISCHARGE SPECTRA RESOLVED IN TIME AND ALONG THE CHANNEL CROSS-SECTION.
I.F.Balashov, M.P.Vanyukov, V.R.Muratov and E.V.Nilov.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 790-1 (Dec., 1960).
In Russian.

Describes a method of recording rapidly changing spark-discharge spectra of small portions of the discharge channel. Light proceeds via a monochromator to an image-converter tube, fitted with an electronic shutter and an image amplifier. Exposures can be varied from 0.1 to 10 $\mu$sec and spectra can be recorded 0.07 to 25 $\mu$sec from the beginning of a discharge. The final image is photographed. The method was applied to a 10 kV discharge across a 4 mm gap in air: N I, N II, and $H_\alpha$ lines were recorded 1, 5, 10 and 21 $\mu$sec from the beginning of the discharge. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

4457 IRREDUCIBLE ERRORS IN THE RECORDING OF SPECTRA. W.Rohmann and M.Schubert.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 89-94. In German.

The optimum relationship between slit-width b, scanning speed g and receptor time-constant z for a recording spectrophotometer is shown to be $zg/b = c$, where c is a constant (of order of magnitude unity) depending on the bandwidth of the amplifier. Recordings of i.r. spectra taken with different values of z are shown as examples. W.T.Welford

4458 INTENSITY MEASUREMENTS IN INFRARED SPECTRA. V.M.Chulanovskii.
Uspekhi fiz. Nauk (USSR), Vol. 68, No. 1, 147-57 (May, 1959). In Russian. English translation in: Soviet Physics—Uspekhi (USA), Vol. 2(68), No. 3, 444-50 (May-June, 1959).

Some current methods of accurate measurement of vibrational absorption band intensities in gases and liquids are described. The errors involved in the determination of the true value of the band parameters such as half-width, absorbance at the peak and integrated area are discussed. In particular, the effect of the finite slit width of the spectrometer and of the time delays in the recording apparatus on the shape of the absorption band is emphasized. In order to avoid errors caused by the latter factor, a point-by-point method of recording the spectra is recommended. In determining the true values of the band parameters, the author applied formulae obtained by Peisakhson, [Bulletin of Leningrad University, No. 5, 129, (1955)]. There is also given a short survey of problems concerning molecular structure which may be solved by means of determining the i.r. absorption band intensities. W.G.Jordan

4459 A DIFFERENTIAL ABSORPTION SPECTROMETER FOR THE INFRA-RED. M.D.Sturge.
J. sci. Instrum. (GB), Vol. 38, No. 3, 96-7 (March, 1961).

A method is described of measuring the small change in absorption coefficient due to the introduction of an impurity into a semiconductor. A chopped monochromatic beam of infrared radiation is passed alternately through the doped and undoped halves of a compound specimen, and the resulting modulation measured. A change of less than $10^{-3}$ $cm^{-1}$ can be observed in the presence of substantial background absorption. The method is illustrated by a measurement on oxygen-doped germanium.

4460 AN f/6 LITTROW GRATING SPECTROGRAPH. J.P.Fallona, H.I.S.Ferguson and R.W.Nicholls.
J. Opt. Soc. Amer., Vol. 51, No. 3, 353-5 (March, 1961).

An inexpensive f/6 Littrow spectrograph was constructed from a plane grating and aerial camera lens. It has a free spectral range of 4000-7000 A on 9 in. of 35 mm film, a reciprocal dispersion of 13 A/mm, and a resolving power (at 5200 A) of 5200.

4461 THE DEFORMATION OF THE LITTROW MIRROR FOR THE REDUCTION OF ASTIGMATISM. H.Becker.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 216-17. In German.

With a spectrometer of aperture ratio 1.4 the astigmatism can be considerably reduced by elastic deformation of the Littrow mirror. G.F.Lothian

4462 INTERFEROMETRICALLY CONTROLLED HYDRAULIC WAVELENGTH DRIVE. G.A.Ameer and W.M.Benesch.
J. Opt. Soc. Amer., Vol. 51, No. 3, 303-9 (March, 1961).

After a discussion of the nature and history of the wavelength drive problem, the construction and operation of an interferometrically controlled hydraulic wavelength drive is described. With servo control, the interferometer end reflector which is maintained in contact with the driven element is advanced linearly to within 0.1 fringe. The speed of the hydraulic drive without servo control suffers from drift amounting to some 3% and arising primarily from temperature change. In its present embodiment the hydraulic drive is being used to rotate the telescope mirror in a 1.5 m Czerny—Turner spectrometer now under construction The results of over-all tests on the drive indicate that this application will result in a spectral scan which is good to 1/1000 Kayser.

4463 CALIBRATION OF A PRISM SPECTROMETER. W.G.Henry and M.R.Meharry.
J. Opt. Soc. Amer., Vol. 51, No. 3, 356-9 (March, 1961).

A numerical method of interpolation and a programme for a Bendix G15D digital computer for the calibration of prism spectrometers is described. The method and programme are of general applicability to any prism in any wavelength region for which there are a sufficient number of calibration points to yield the desired precision. The method is applied to a fused-quartz Perkin—Elmer model 99 double-pass spectrometer. A list of absorption peaks and emission lines, in the wavelength range 2300-26 000 A, is given. The precision of the calibration is as good as the resolution and the reproducibility of the drum setting which are about equal for this instrument and this prism in this wavelength range. A theoretical foundation for the McKinney and Friedel relationship is given and its limitations are discussed.

4464 REAL SPECTRAL APPARATUS. S.G.Rautian.
Uspekhi fiz. Nauk (USSR), Vol. 66, No. 3, 475-517 (Nov., 1958). In Russian. English translation in: Soviet Physics—Uspekhi (USA), Vol. 1(66), No. 2, 245-73 (Nov.-Dec., 1958).

Survey paper dealing with the instrumental function of spectral apparatus (slit-width function, fringe-intensity function, etc.) and the problem of computing the real spectrum from that given by the instrument. 130 references. W.T.Welford

4465 THE BASIC PRINCIPLES OF RECORDING SPECTRA IN INFRARED SPECTROPHOTOMETERS. A.F.Mal'nev, M.P.Esel'son and L.S.Kremenchugskii.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 3-16 (Jan.-Feb.). In Russian.

The basic principles are reviewed. The commonest designs of infrared apparatus are described, and, in less detail, apparatus used in the visible and ultraviolet regions. 195 references. [English translation in: Instrum.exper. Tech. (USA), No. 1, 1-15 (Jan.-Feb., 1958; publ. April, 1959)].

4466 AN ANALYSIS OF THE TRACKING SYSTEM OF DOUBLE-BEAM INFRARED SPECTROMETERS [TYPE IKS-2(14)]. L.A.Gribov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 65-9 (March-April). In Russian.

The differential equation of the tracking system is deduced. A practical method of choosing the optimum operating conditions of the instrument is given on the basis of an analysis of its solution. An attempt is made to determine the nature of the distortions which are introduced by the amplifying and recording parts of the instrument in the determination of the wavelength, half-width and intensity of absorption bands. A method of determining the working range of scanning velocities is also given. [English translation in: Instrum. exper. Tech. (USA), No. 2, 249-54 (March-April, 1958; publ. April, 1959)].

4467 THE LONG-WAVELENGTH INFRARED EMISSION FROM GAS-DISCHARGE LAMPS. W.Boldt and H.Reimann.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 293-7 (1960). In German.

Gives curves of the relative intensities (from a monochromator) in the region $\lambda = 100$-$350$ $\mu$ for various commercial mercury lamps (at pressures of 1.5-75 atm), a xenon lamp and a Globar. The mercury-lamp emission decreased with increasing pressure and the other two sources had weaker emissions than the low-pressure mercury-lamp. For the l.p. mercury lamp the ratio, quartz-wall emission/arc-discharge emission was 1/4 at 200 $\mu$. G.F.Lothian

INSTRUMENTAL EFFECTS IN INFRARED GAS SPECTRA AND SPECTROSCOPIC TEMPERATURE MEASUREMENTS. See Abstr. 4378

4468 OBSERVATIONS ON THE CHOICE OF LIGHT SOURCES FOR THE VACUUM ULTRAVIOLET. T.Tuchscheerer and W.Müller.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 6, 263-8 (1960). In German.

A comparison of the sliding spark in vacuum and the gas-filled spark chamber. With a given type of Feussner excitation, the gas-filled method is less critical of conditions; the intensity depends on the gas pressure and with $N_2$ is greatest at 1 atm. G.F.Lothian

4469 LIGHT SOURCES FOR THE EXCITATION OF THE RESONANCE FLUORESCENCE OF ALKALI METALS. K.Hoffmann and R.Seiwert.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 4, 161-77 (1960). In German.

Different types of alkali metal vapour lamp were examined for

eir suitability in exciting the resonance lines of Na, K and Cs, easurements being made of the temperature dependence of the uorescence. Line profiles obtained by Fabry–Perot measure- ents showed the Druyvesteyn cataphoresis lamp to emit lines ith much less self-absorption than in other types. The structure the Cs 8521 A line was used to calculate the hyperfine structure nstant of the ground state. Measurements were made of absorp- on and re-emission of a resonance line in K vapour between 300 id 500°K. S.T.Henderson

STIMULATED I.R. EMISSION FROM $CaF_2$:U AS STRONG C.W. IGHT SOURCE. See Abstr. 3873

# PHYSICAL OPTICS

*(Luminescence is included under Solid-State Physics, Liquid State, or Gaseous State)*

4470 ON SOME NEW PROBLEMS OF BOUNDARY OPTICS OF ABSORBING SUBSTANCES. H.Pohlack.
Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 961) p. 369-73. In German.
Various means of apparent light traps are systematized, the eversal of rays affecting transmissivity and reflectivity to a fferent extent. R.A.Weale

4471 RELATION BETWEEN SURFACE ROUGHNESS AND SPECULAR REFLECTANCE AT NORMAL INCIDENCE.
.E.Bennett and J.O.Porteus.
. Opt. Soc. Amer., Vol. 51, No. 2, 123-9 (Feb., 1961).
Expressions relating the roughness of a plane surface to its pecular reflectance at normal incidence are presented and are erified experimentally. The expressions are valid for the case hen the root mean square surface roughness is small compared o the wavelength of light. If light of a sufficiently long wavelength s used, the decrease in measured specular reflectance due to urface roughness is a function only of the root mean square height f the surface irregularities. Long wavelength specular reflectance easurements thus provide a simple and sensitive method for ccurate measurement of surface finish. This method is particular- y useful for surface finishes too fine to be measured accurately by onventional tracing instruments. Surface roughness must also be onsidered in precise optical measurements. For example, a non- egligible systematic error in specular reflectance measurements ill be made even if the root mean square surface roughness is less an 0.01 wavelength. The roughness of even optically polished urfaces may thus be important for measurements in the visible nd ultraviolet regions of the spectrum.

4472 REFLECTANCE OF AN INHOMOGENEOUS THIN FILM. S.F.Monaco.
. Opt. Soc. Amer., Vol. 51, No. 3, 280-2 (March, 1961).
An exact formula for the intensity reflectance of light incident ormally on a nonabsorbing nonhomogeneous thin film is derived or the case where the refractive index changes exponentially with ilm thickness and the film is bounded on either side by nonabsorbing omogeneous semi-infinite media. A formula for the phase change t reflection is also derived.

4473 APPARATUS FOR THE CONTROLLED DEPOSITION OF OPTICAL FILM SYSTEMS.
V.Steckelmacher, J.M.Parisot, L.Holland and T.Putner.
Vacuum (GB), Vol. 9, No. 3-4, 171-85 (July.-Sept., 1959; publ. 1960).
Some of the problems of producing multi-layer interference ystems are discussed in relation to the design of the deposition lant and film thickness control apparatus. A vacuum plant is escribed in which multi-layer films of evaporated or sputtered ayers can be deposited in sequence on a rotating plane surface. The thickness of the individual films is controlled by measuring heir reflectance or transmittance during deposition with a modu- ated-beam photometer of high sensitivity and stability. The nonitoring light is chopped at frequency of 33 c/s and the output rom the photocell amplified by a tuned low frequency amplifier. The conditions for obtaining minimum light scattering in the instru- ent are discussed. The design of the low frequency amplifier is considered in relation to noise level and filter design. In conclusion the use of the combined apparatus is described for producing a variety of optical systems such as $TiO_2$ beam-splitters, $Bi_2O_3$–Au–$Bi_2O_3$ heat reflecting mirrors, two-layer anti-reflection coatings of $Bi_2O_3$–$MgF_2$ and all-dielectric broad-band filters of $MgF_2$–ZnS.

4474 DOUBLE-PASSED FABRY–PEROT INTERFEROMETER.
P.Hariharan and D.Sen.
J. Opt. Soc. Amer., Vol. 51, No. 4, 398-9 (April, 1961).
Increase contrast and resolution can be obtained with the Fabry–Perot interferometer by reflecting the transmitted beams back through the instrument. An arrangement for this purpose is described in which the double-passed interference pattern is isolated by means of a simple polarizing system.

INTERFEROMETRIC TESTING OF THE PLANENESS OF LONG BEDS. See Abstr. 4296

4475 SPECTRAL ANALYSIS OF "BEATS" BETWEEN TWO-DIMENSIONAL STEREOSCOPIC CINEMATOGRAPHY SYSTEMS [MOIRE PATTERNS]. N.K.Ignat'ev.
Kristallografiya (USSR), Vol. 5, No. 3, 383-9 (May-June, 1960). In Russian. English translation in: Soviet Physics–Crystallography. (USA), Vol. 5, No. 3, 362-7 (Nov.-Dec., 1960).
A method of spectral analysis is discussed whereby moiré images appear when a mask with a lattice distribution of openings is superimposed on an image which itself consists of many periodically recurrent figures which also have a lattice distribution.

4476 EFFECT OF PARTICLE SEPARATION ON THE REFLECTANCE OF SEMI-INFINITE DIFFUSERS.
W.R.Blevin and W.J.Brown.
J. Opt. Soc. Amer., Vol. 51, No. 2, 129-34 (Feb., 1961).
It is shown experimentally that the reflectance of a semi-infinite suspension of particles in a nonabsorbing matrix is independent of particle concentration, except at high concentrations where the reflectance usually falls.

4477 LIGHT SCATTERING BY SOLUTIONS OF SURFACE ACTIVE AGENTS. H.C.Parreira.
An. Acad. Brasil. Cienc., Vol. 32, No. 2, 207-16 (1960).
Results are given for the dodecylpyridinium iodide agent in potassium iodide. They show the influence of neutral electrolyte concentration on the micelle size of the agent. Scattering measurements were carried out at 25 ± 0.1°C and 5461 A using an apparatus described previously [Ottewill and Parreira, J. phys. Chem. (USA), Vol. 62, 912 (1958)]. Concentrations were measured using a spectrophotometer and refractive index was obtained using a Zeiss Löwe–Haber interferometer. A discussion which considers the weight, charge and degree of ionization of the micelle is presented.
H.G.Jerrard

4478 LIGHT SCATTERING FUNCTIONS FOR SPHERICAL PARTICLES WITH m = 1.65 (0.05) 1.85.
J.E.Meehan and Z.Z.Hugus.
J. Opt. Soc. Amer., Vol. 51, No. 3, 260 (March, 1961).
Mie theory calculations are presented for scattering coefficient and forward scattering by spherical particles with m = 1.65 (0.05) 1.85 and $\alpha$ up to 6.0.

4479 A THEORY OF THE RAMAN SCATTERING OF LIGHT.
P.P.Shorygin and L.L.Krushinskii.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 337-40 (July 11, 1960). In Russian.
Derives and discusses classical and quantum expressions for the intensity of Raman lines excited with frequencies f which approach the frequencies $f_e$ of electronic–vibrational transitions, i.e. where $(f_e - f) \leq 10^3$ cm$^{-1}$. [English translation in: Soviet Physics — Doklady (USA), Vol. 5, No. 4, 790-3 (Jan.-Feb., 1961)].
A.Tybulewicz

THEORY OF LIGHT SCATTERING BY THIN RODLIKE MACROMOLECULES IN A LIQUID SUBJECTED TO SHEAR. See Abstr. 4342

AUTOMATIC PHOTOMETER FOR MEASURING THE ANGULAR DISSYMMETRY OF LIGHT SCATTERING. See Abstr. 4431

4480 PULSE METHOD FOR MEASURING KERR'S CONSTANT. A.Piekara and R.Konopka.
Brit. J. appl. Phys., Vol. 12, No. 2, 50-2 (Feb., 1961).

A pulse method is proposed for measuring Kerr's effect as produced by a single saw-form electric field pulse of a duration of $5 \times 10^{-5}$ sec. The method served for investigating the electro-optical birefringence of liquids whose conductivity was so high as to rule out the use of static methods of measurement. Kerr's constant was measured in o-nitrotoluene, m-nitrotoluene and nitrobenzene, these liquids presenting a conductivity ranging from $10^{-7}$ to $4 \times 10^{-11}$ mhos/cm.

4481 INFRARED POLARIZERS OF THE REFLECTION TYPE. S.Takahashi.
J. Opt. Soc. Amer., Vol. 51, No. 4, 441-4 (April, 1961).

Describes infrared polarizers made by placing a large number of glass plates coated with selenium in parallel. The aperture is $12 \times 9$ cm. The beam is reflected two or four times in the apparatus and emerges in the same direction as that of the incident beam. When the incident beam is not perfectly parallel and has the maximum obliquity of 0.05 rad, the degree of polarization obtained by two reflections on the selenium surfaces is measured to be 99.9%, while the theoretical value is 99.98%. For an ordinary use, a single reflection by selenium will be sufficient and the aluminized surface may be substituted for the remaining reflection. In this case, greater intensity of emergent beam can be obtained at 99.5% degree of polarization.

4482 CORRELATION BETWEEN PHOTONS IN PARTIALLY POLARIZED LIGHT BEAMS. E.Wolf.
Proc. Phys. Soc. (GB), Vol. 76, Pt 3, 424-6 (Sept., 1960).

It is shown theoretically that the mean square fluctuation in the photoelectron emission rate in a detector exposed to a partially polarized light beam depends on the degree of polarization. If two detectors are exposed to portions of the same beam the correlation between their respective photon counting rates depends on the polarization and can in principle be used to measure it.

W.T.Welford

# COLORIMETRY . PHOTOGRAPHY

4483 ISOGRADIENT APPARATUS FOR THE EVALUATION OF PHOTOGRAPHIC IMAGES. M.Maly.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 349-53. In German.

A transparent relief of the photographic image is produced by an etching process. Two optical systems are shown which produce a "contoured" image either in black and white or in colour, to show lines of equal density. Typical results are shown. R.W.Fish

4484 THEORETICAL CONSIDERATIONS ON THE QUANTUM EFFICIENCY OF PHOTOGRAPHIC DETECTORS. H.J.Zweig.
J. Opt. Soc. Amer., Vol. 51, No. 3, 310-19 (March, 1961).

The relation of theoretical characteristic curves for monolayer ensembles of go—no-go detectors (emulsion grains) to quantum efficiency is developed. It is shown that the statistical fluctuations in the incident photons, as well as the fluctuations in the number of detectors made developable by a given exposure, preclude the possibility of achieving a quantum efficiency of unity. The maximum quantum efficiency achievable depends on the number of photons required for developability as well as on the exposure. The latitude requirements for such an ensemble impose further restrictions on the achievable quantum efficiency.

4485 SYSTEMS ANALYSIS OF THE PHOTOGRAPHIC PROCESS. II. TRANSFER FUNCTION MEASUREMENTS. D.H.Kelly.
J. Opt. Soc. Amer., Vol. 51, No. 3, 319-30 (March, 1961).

For Pt I, see Abstr. 3660 of 1960. The special techniques required to measure the photographic transfer functions defined in Pt I are described, and detailed methods of computation are given. A photographic procedure for separating isotropic optical losses into lens and film components is discussed; results of this method are compared with data obtained by different methods at other laboratories. Illustrative measurements of both optical and chemical transfer functions are presented for deveral different emulsions and processing techniques. These data are consistent with the model proposed in Pt I and with microdensitometer traces of "knife-edge" exposures. It is indicated that the term "adjacency effects" should be abandoned in favour of the more general formulations used here.

4486 SOME PROPERTIES OF PHOTOGRAPHIC IMAGE RECORDING. J.S.Wilczynski.
Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 17-35 (Jan., 1961).

An investigation of both the linear and non-linear parts of the photographic process was carried out using the concept of optical frequency response for the description of the contrast degradation resulting from diffusion of light in the emulsion which is the linear part of the process. An analogy between the operation of a low-pass passive filter and valve and photographic image recording is established and a simple theory for calculating the resulting opacity in a photographic image is described. This latter introduces the idea of harmonic distortion to describe the non-linear part of the process. The experimental results obtained by means of an optical Fourier analyser for transparencies were found to be in good agreement with the theory. A description of the instrument is given in the first part of the paper. Some other applications of the theory are considered.

4487 VERY HIGH SPEED DUAL-PURPOSE IMAGE-CONVERTER CAMERA. F.H.Grover.
J. sci. Instrum. (GB), Vol. 38, No. 3, 86-91 (March, 1961).

A laboratory instrument which uses a commercially available image converter tube as a fast shutter for very short exposure photographs of high-velocity self-luminous phenomena is described. Exposure times of ten millimicroseconds are obtained with pulses derived from a line pulse circuit having a coaxially constructed thyratron switch. The equipment may also be used for streak photography with a choice of sweep times in the range 1-25 $\mu$sec.

PHOTOGRAPHIC SYSTEM FOR LARGE HYDROGEN BUBBLE CHAMBERS. See Abstr. 3097

4488 DISTORTION IN PHOTOGRAMMETRY. H.Schoeler.
"Optics of all wavelengths" Meetings, Jena, 1958 (see Abstr. 224 of 1961) p. 192-9. In German.

Typical equipment for photogrammetry is briefly described. The Gaussian definition of distortion is extended to cover the photogrammetric distortion from a calibrated principal distance. The use of compensating plates for removal of residual distortion is mentioned. R.W.Fish

4489 THE PRACTICAL DETERMINATION OF THE PHOTOGRAMMETRIC DISTORTION OF ULTRA-WIDE-ANGLE OBJECTIVES FOR FINITE CONJUGATES. E.Wolf.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 209-15. In German.

The methods of determining distortion for lenses with the object at infinity are well known. For plotting equipment, such as the Multiplex, it is necessary to determine the distortion at finite conjugates. Equipment for making such measurements is described and results quoted for a projection lens covering 122° field.

R.W.Fish

ACOUSTICO—OPTICAL PICTURE TRANSFORMATION BY MEANS OF PHOTOGRAPHIC FILMS. See Abstr. 4416

# HEAT . RADIATION

4490 SOME VARIANTS OF NON-STATIONARY METHODS FOR MEASURING THE THERMAL CONDUCTIVITY OF SEMICONDUCTORS. A.F.Chudnovskii.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2938-44 (Nov., 1960). In Russian.

Discusses some difficulties met in steady-state methods and describes some modifications of non-stationary methods, mainly of the method used by Ioffe and Ioffe (Abstr. 5992 of 1953; 4511 of 19

measure simultaneously the thermal conductivity and diffusivity i the heat capacity. [ English translation in: Soviet Physics— id State (USA)]. R.Berman

4491 TRANSIENT STATE HEAT TRANSFER AND DIFFUSION PROBLEMS. Tung Tsang.
lustr. engng. Chem. (USA), Vol. 52, No. 8, 707-10 (Aug., 1960).
Considers the problem of heat conduction or diffusion when nditions are slightly non-linear. A perturbation method is ggested, starting from the known form of the solution of the linear oblem for large times. Some special cases are considered, and mparison with some numerical computations is made, agreement ing better than expected. H.N.V.Temperley

4492 CONDUCTION—CONVECTION FROM A CYLINDRICAL SOURCE WITH INCREASING RADIUS. H.R.Bailey.
art. appl. Math. (USA), Vol. 18, No. 4, 325-33 (Jan., 1961).
A quasi-stationary-state solution is obtained for the case of a ite convection coefficient and with the radius increasing at a nstant velocity. A transient solution is obtained for the case of infinite convection coefficient and with the radius increasing at a te proportional to the square root of time. In the latter case, an plicit evaluation of an integral form of the solution is obtained by owing that the solution, in a certain coordinate system, is inde- ndent of time and thus the partial differential equation reduces to ordinary differential equation which is solved explicitly.

4493 A CERTAIN STOCHASTIC HEAT FLOW PROBLEM. O.Hellman.
n. Univ. Turku. AI (Finland), No. 43, 10 pp. (1960).
Considers the one-dimensional heat conduction problem when e temperature of the inside of a vessel is constant, but that outside ries in a random manner. An asymptotic solution is given when e temperature is maintained at $\beta_1$ for a time interval $T_1$, at $\beta_2$ for urther interval $T_2$, etc., in terms of the distribution fractions for nd T. In the limit of a large number of intervals, the asymptotic stribution of heat flow becomes independent of that of T, but re- ins dependent on the distribution of $\beta$. H.N.V.Temperley

4494 FORCED CONVECTION [OF HEAT] IN A PLANE LAYER IN [A SYSTEM OF] AXIAL SYMMETRY.
.I.Rubinshtein.
okl. Akad. Nauk SSSR, Vol. 135, No. 3, 553-6 (Nov. 21, 1960).
Russian.
The familiar equation governing the conduction of heat (in ylindrical polar coordinates) is augmented by a linear term etermining convection and an inhomogeneity determining a stribution of heat sources. This equation is solved by an expansion ocedure. There is no attempt to obtain relations which could be rrelated with measurements. [English translation in: Soviet hysics—Doklady (USA)]. R.Eisenschitz

4495 ON A CONTACT HEAT CONVECTION PROBLEM. L.I.Rubinshtein.
okl. Akad. Nauk SSSR, Vol. 135, No. 4, 805-8 (Dec. 1, 1960).
Russian.
Determines the temperature field in an anisotropic layer hen heat is injected (focused) through a single slit. The problem solved by means of Laplace integral transforms and the tempera- re distribution is obtained under equilibrium conditions. [English anslation in: Soviet Physics — Doklady (USA)]. J.K.Skwirzynski

4496 A UNIQUENESS THEOREM FOR THE EQUATION OF PROPAGATION OF HEAT BY NATURAL CONVECTION.
.M.Zoli.
C Accad. Naz. Lincei (Italy), Vol. 28, No. 2, 173-8 (Feb., 1960).
Italian.
An analogous theorem to that derived by Graffi [C.R. Acad. Sci. France), Vol. 249, No. 18, 1741 (Nov. 2, 1959)] for the flow of an compressible viscous fluid, is obtained for the equations of berbeck and Boussinesq which govern the propagation of heat. S.Weintroub

HEAT TRANSPORT BY CONVECTION IN PRESENCE OF A AGNETIC FIELD. See Abstr. 4710

4497 PHENOMENOLOGICAL ASPECTS OF THE RADIATION LAW. H.Hartmann.
Naturwissenschaften (Germany), Vol. 47, No. 23, 536-7 (1960).
In German.
Discusses briefly a universal energy radiation law of which Planck's law and Euler's theorem are the limiting cases. S.J.St-Lorant

4498 SPECTRAL EMISSIVITY OF 99.7% ALUMINIUM BETWEEN 200 AND 540°C. P.M.Reynolds.
Brit. J. appl. Phys., Vol. 12, No. 3, 111-14 (March, 1961).
Results are given for surfaces of roughness 3 $\mu$ in., 115 $\mu$ in. and anodized aluminium within the wavelength range 1 to 14 $\mu$. The spectral emissivity varied strongly with surface roughness and oxidation, but only slightly with temperature. Typical values at wavelengths 2 and 8 $\mu$ respectively were 0.09 and 0.04 for polished, 0.30 and 0.24 for roughened, 0.30 and 0.20 for anodized aluminium. Natural oxidation slightly increased the spectral emissivity at all wavelengths below 9 $\mu$ and had a marked effect between 10 and 12 $\mu$. An anodic oxide film increased the spectral emissivity beyond 10 $\mu$ to greater than 0.70. The significance of these variations to radiation pyrometry is briefly discussed.

4499 DIELECTRIC BOLOMETER: A NEW TYPE OF THERMAL RADIATION DETECTOR. R.A.Hanel.
J. Opt. Soc. Amer., Vol. 51, No. 2, 220-4 (Feb., 1961).
Thermal detectors for the infrared, such as thermocouples and bolometers, are limited in their ultimate sensitivity predominantly by Johnson noise rather than by temperature noise. Low noise figures are hard to achieve, since the Johnson noise dominates temperature noise, which is the only essential noise for thermal detectors. Some materials show a temperature dependence of their dielectric constant sufficiently high to make a new type of bolometer feasible. The basic theory of a dielectric bolometer, as shown here, promises noise figures below 3 dB even at chopper frequencies well above the $1/\tau$ value of the detector. Ferroelectrics such as barium-strontium titanate and others seem to be well suited for radiation-cooled dielectric bolometers.

4500 THE BUBBLE MECHANISM OF SHOCK TRIGGERED COMBUSTION IN LIQUIDS. R.I.Soloukhin.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 2, 311-12 (Jan. 11, 1961).
In Russian.
Shock waves passing through a combustible liquid may start combustion and their action is intensified by the presence of bubbles of air. For the purpose of investigating this effect the pressure in the neighbourhood of a bubble in water was measured during the time (approx. 10 $\mu$sec) in which a shock front passed by. Also the rate of compression of a bubble measured during the process of shock triggering in an acetylene—oxygen mixture. The observations do not agree quantitatively with the result of a simple hydrodynamical calculation. Further experiments with a hydrogen—oxygen mixture show that combustion starts at a temperature of 891°K. [English translation in: Soviet Physics — Doklady (USA)]. R.Eisenschitz

EFFECT OF CHEMICAL REACTION ORDER ON FLAME PROPAGATION. See Abstr. 4095

4501 THERMOCOUPLES. J.Bailleul-Langlais.
Vide (France), Vol. 14, 348-56 (Nov.-Dec., 1959). In French and English.
A review of the theoretical aspects of the use of thermocouples and their realization in practice. E.G.Knowles

4502 THERMOCOUPLES FOR USE IN CARBON ATMOSPHERES. M.R.Nadler and C.P.Kempter.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 43-7 (Jan., 1961).
Criteria are discussed for using thermocouples in carbon atmospheres above 2000°C. Experimental data are given for W/Re, W/W—25 Re, Re/W—25 Re, graphite/Re, and graphite/Ir thermocouples in carbon atmospheres from room temperature to 2200°C. Reaction temperatures of carbon with thoria, urania, and yttria were measured to be below 1730°, 1620°, and 1590°C respectively.

4503 MAIN PRINCIPLES OF THE DESIGN OF THERMISTOR THERMOMETERS. J.Vepřek.
Slaboproudy Obzor (Czechoslavakia), Vol. 21, No. 12, 697-704 (1960). In Czech.

The principal characteristics of bead-type thermistors are discussed; in particular, the dependence of their resistance on temperature and current is analysed. It is pointed out that a bead thermistor can be used as a temperature transducer and, by connecting it in a resistance-bridge circuit, a thermistor thermometer can be designed. The operating conditions of the thermistor in the bridge are considered, and design formulae for the following cases are derived: (1) multi-purpose thermometer with a direct-reading meter (the diagonal resistance is much lower than the resistances of the bridge arms), (2) single-purpose thermometer with direct indication, (3) multi-purpose thermometer with an indirect-indicating instrument (the diagonal resistance is much higher than the resistance of the bridge arms), and (4) single-purpose thermometer with indirect indication. It is shown that the thermometers are stable and accurate, if the thermistor operating current is suitably chosen. Two practical thermometers for temperatures of 35-42°C and 30-60°C are described. R.S.Sidorowicz

4504 RESISTANCE THERMOMETERS FOR LOW TEMPERATURES. C.R.Barber.
Progress in cryogenics, Vol. 2 (see Abstr. 4509 of 1961) p. 147-71

Reviews the resistance—temperature characteristics of pure metals, leaded phosphor-bronze elements, manganin and constantan, semiconductor resistance elements, carbon thermometers, and the design and calibration from 20°-90°K of platinum resistance thermometers. 33 refs. J.B.Birks

4505 A RAPID-RESPONSE RESISTANCE THERMOMETER. V.A.Zamkov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 134-6 (Jan.-Feb.). In Russian.

A detailed description is given of a 2 × 5 × 50 mm thermometer (response 0.5 sec) which meets the specifications of the International Temperature Scale. The thermometer is hermetically sealed and can be mounted in the fluid of thermostats and calorimeters. [English translation in: Instrum. exper. Tech. (USA), No. 1, 150-1 (Jan.-Feb., 1958; publ. April, 1959)].

4506 CALCULATION AND DESIGN OF PRECISION THERMOSTATS.
V.V.Grigor'yants and M.E.Zhabotinskii.
Pribory i Tekh Eksper. (USSR), 1958, No. 1, 106-9 (Jan.-Feb.). In Russian.

The theory is given of a thermostat which ensures a continuous regulation of the temperature. The design is considered of thermostats which enable the temperature variations in a space to be controlled to within 0.001°C. [English translation in: Instrum. exper. Tech. (USA), No. 1, 117-21 (Jan.-Feb., 1958; publ. April, 1959)].

4507 SMALL HIGH-TEMPERATURE VACUUM FURNACE. G.Arthur and J.H.Priest.
J. sci. Instrum. (GB), Vol. 38, No. 3, 80-2 (March, 1961).

A small high-temperature vacuum furnace, using tantalum as the heating element, is described. The main features of the furnace are its simplicity of construction, the absence of internal water cooling and the comparatively low power requirements (2.5 kW at 2200°C).

4508 A HIGH-TEMPERATURE SILIT FURNACE. V.I.Shelyubskii and V.V.Gusarov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 138-9 (Jan.-Feb.). In Russian.

A description is given of the construction and control circuit of a furnace allowing a temperature of 1500°C to be maintained for a considerable time with a temperature gradient in the working space of 1 - 2°C and with an automatic control precision of ± 1°C. The construction is such as to allow working with substances whose vapours corrode silit heaters. [English translation in: Instrum. exper. Tech. (USA), No. 1, 154-5 (Jan.-Feb., 1958; publ. April, 1959)].

4509 PROGRESS IN CRYOGENICS. Vol. 2. Edited by K.Mendelssohn.
London: Heywood and Co. (1960) 280 + vii pp.

This volume contains a preface and eight review articles. Abstracts of the articles will appear in this or subsequent issues of Physics Abstracts. J.B.Birks

4510 THE STORAGE AND HANDLING OF CRYOGENIC LIQUIDS. G.H.Zenner.
Progress in cryogenics, Vol. 2 (see Abstr. 4509 of 1961) p. 1-40.

Deals with the principal cryogenic liquids: oxygen, nitrogen, argon, methane, fluorine, hydrogen and helium. The topics discusse include insulation, container design, storage containers, pressure transfer, rotary and reciprocating pumps for liquid $O_2$ and $N_2$, liquid meters, cold converters, customer installations, liquid piping transport equipment, warm converters, aircraft oxygen systems, and liquid $CH_4$, $F_2$, $H_2$ and He. 51 refs. J.B.Birks

4511 THE GAS REFRIGERATING MACHINE AND ITS POSITION IN CRYOGENIC TECHNIQUES. J.W.L.Kohle
Progress in cryogenics, Vol. 2 (see Abstr. 4509 of 1961) p. 41-67.

The theory, design performance and applications of the Philips gas refrigerating machine are described. The relation of the machine to existing refrigeration methods is discussed. J.B.Birks

# CHANGE OF STATE

*(Solid-state phase transformations are included primarily under Structure of Solids)*

4512 ON THE STATIONARY FLOW OF VAPOUR. S.Fujita.
Kumamoto J. Sci. A (Japan), Vol. 4, No. 3, 210-22 (Feb., 1960).

Vaporization is maintained steadily through a closed U-tube, with the legs immersed in two heat resevoirs at different fixed temperatures. Under these simple conditions, the rate of vaporization is related to the temperature difference, the pressure gradient of the vapour, the pressure of the other gas in the tube, and the sectional area and form of the tube. Calculated values for the flow of water vapour in air at normal and reduced pressures are general consistent with observed values. P.Gray

4513 THERMODYNAMICS OF THE VAPORIZATION OF $Cr_2O_3$ DISSOCIATION ENERGIES OF CrO, $CrO_2$ AND $CrO_3$.
R.T.Grimley, R.P.Burns and M.G.Inghram.
J. chem. Phys. (USA), Vol. 34, No. 2, 664-7 (Feb., 1961).

The vaporization of $Cr_2O_3$ under neutral and oxidizing conditions was studied using mass spectrometric methods. The vaporization proceeds with the formation of Cr, CrO, $CrO_2$, O, and $O_2$ as the principal gaseous species. Under oxidizing conditions $CrO_3$ was also observed. Dissociation energies of the gaseous molecules are $D_0°(CrO) = 101.1 \pm 7$ kcal/mole, $D_0°(CrO_2) = 227.1 \pm 15$ kcal/mole, and $D_0°(CrO_3) = 341 \pm 20$ kcal/mole.

4514 VAPOR PRESSURE OF SILICON AND THE DISSOCIATION PRESSURE OF SILICON CARBIDE.
S.G.Davis, D.F.Anthrop and A.W.Searcy.
J. chem. Phys. (USA), Vol. 34, No. 2, 659-64 (Feb., 1961).

The vapour pressure of silicon and the dissociation pressure of silicon carbide were obtained from total weight loss experiments with Knudsen effusion cells. Combination of the measured data with known entropies yields at 298°K for the heat of sublimation of silicon to silicon atoms 108.4 ± 3 kcal and for the heat of the reaction $SiC(s) = Si(g) + C(s)$ 126.0 ± 3 kcal. From the pressure studies and from phase equilibria for the condensed phase silicon—carbon system, the heats of formation for both the cubic and hexagonal modifications of silicon carbide are concluded to be −15.0 ± 2 kcal.

# THERMODYNAMICS

*(See also Statistical Mechanics)*

4515 STATEMENT OF THE FIRST LAW OF THERMODYNAMICS. R.E.Warner.
Amer. J. Phys., Vol. 29, No. 2, 124 (Feb., 1961).

The author proposes that the law should be stated $dE = \delta Q - \delta W$ instead of $dE = \delta Q - \delta W^*$, where dE is the change of energy of a system during an infinitesimal process, $\delta Q$ is the heat energy which

ows into the system from its surroundings, δW is the work done the system by external forces, δW* is the work done by the stem on its surroundings. An example in support is quoted.
E.G.Knowles

4516 THE NON-LINEAR THERMODYNAMICS OF IRREVERSIBLE PROCESSES. I.F.Bakhareva.
kl. Akad. Nauk SSSR, Vol. 135, No. 2, 350-3 (Nov. 11, 1960). Russian.

By retaining the third-order terms in the expansion of ΔS, e deviation of the entropy S from its equilibrium value, two forms Onsager's dynamical equations are obtained, one linear and the her non-linear. Together they express the kinetic law in a form lid throughout the whole kinetic region of certain processes, and t only near equilibrium. An example is given of the application the result to a chemical reaction consisting of a sequence of two versible bimolecular stages. G.A.Chisnall

4517 THE ENTROPY OF GAS MIXTURES. N.J.Ionescu-Pallas.
ud. Cercetari Fiz. (Roumania), Vol. 8, No. 4, 457-67 (1957). Roumanian.

Deals with an isothermal mixture of an arbitrary number of ases. From the conditions of the conservation of the initial roportions of the mixture and from the condition of additivity of ne entropy of the mixture, with respect to volume, for an finitesimal increase in the number of particles of the system, the artial differential equation is obtained representing the dependence f the entropy on the numbers of particles of the different chemical pecies of the mixture. By comparison of the expression obtained or S (the entropy) with the asymptotic expression for S at small ensities, the well-known thermodynamic expression for the entropy f a mixture of gases can be deduced. In this way the hypothesis ntroduced by Gibbs, of semi-permeable walls for the separation of ne components of the mixture, can be eliminated. S.Weintroub

4518 NEGATIVE AND LIMITING TEMPERATURES. Yu.B.Rumer.
h. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1899-1902 (June, 1960). n Russian.

It is shown that the possibility of existence of negative tempera- ures and upper limits of positive temperatures in a thermodyna- ical system is connected in mathematical statistical physics with ne analyticity of the statistical state sum as a function of the eciprocal of temperature. [English translation in: Soviet Physics—ETP (USA), Vol. 11, No. 6, 1365-7 (Dec., 1960)].

# LOW-TEMPERATURE PHYSICS

4519 THE 1958 SCALE OF TEMPERATURES FOR THE LIQUID HELIUM-4 REGION. H.Van Dijk.
rogress in cryogenics. Vol. 2 (see Abstr. 4509of 1961) p. 121-45.

The temperature scale is defined by a table, which is presented, f the saturation vapour pressure of $He^4$ between 0.5° and 5.22°K. elated matters discussed include the boiling points of $He^4$, ydrogen and oxygen, the thermodynamic pT relation, the evalua- on of $L_0$ (heat of vaporization at 0°K), the λ-point pressure and emperature, thermodynamic calculation of the scale up to the -point, extension of the scale beyond the λ-point, numerical alculation of the 1958 scale, and vapour pressure and temperature. 3 refs. J.B.Birks

4520 EXPERIMENTS ON NUCLEAR COOLING. M.V.Hobden and N.Kurti.
Phil. Mag. (GB) (Eighth Ser.), Vol. 4, 1092-5 (Sept., 1959).

In continuation of earlier work (Abstr. 2137 of 1957) further experiments were carried out on the isentropic demagnetization of copper nuclei in the metal using new apparatus and improved techniques. These lead to a somewhat different interpretation and give the interaction temperature $\theta_n$, corresponding to the separation of successive nuclear levels in the internal field, as $1.7 \times 10^{-7}$ °K. The temperature dependence of the nuclear spin–lattice relaxation time is characteristic of energy transfer from the nuclear spins to the conduction electrons at the lattice temperature. The relaxation time is strongly field-dependent. J.M.Baker

4521 THE PRODUCTION OF TEMPERATURES IN THE REGION OF ABSOLUTE ZERO. K.Kreutzer.
VDI Z. (Germany), Vol. 103, No. 3, 89-97 (Jan. 21, 1961). In German.

Review.

PROGRESS IN CRYOGENICS. See Abstr. 4509

THE STORAGE AND HANDLING OF CRYOGENIC LIQUIDS. See Abstr. 4510

# Liquid and Solid Helium

DERIVATION OF THE LANDAU THEORY OF FERMI LIQUIDS. See Abstr. 4284

4522 SPECIFIC HEATS OF HELIUM VAPOURS BELOW 4.2°K. J.de Laet.
Verhandl. K. Vlaamse Acad. Wetensch. (Belgium), No. 66, 52 pp. (1960). In Flemish, with summary in French.

The object of this research was to determine the sound velocity W in gaseous helium at different temperatures below the normal boiling point, with the aim of establishing an acoustical method of thermometry in this region. Use was made of the experimental data for deducing the specific heats $C_p$ and $C_v$ and their ratio. In the first part of the work, the precision of the results was tested systematically with $CO_2$, $O_2$, $H_2$ and He. The theoretical expression

$$W = [(P/\rho)C_p/C_v]^{1/2}$$

is actually valid only for an infinite medium of propagation. Is the Kirchhoff correction for an infinite tube sufficient, or is it necessary to apply that of Thiesen, which takes account of the finite length? All experiments show that the results obtained with only the Kirchhoff correction agree with theory the better the lower the temperature and pressure and the larger the number of antinodes in the system of stationary waves. The second part begins with eight sets of measurements of the sound velocity in helium, as a function of pressure at temperatures varying from 4.288° to 2.078°K. From this are deduced: (1) a temperature scale; (2) the specific heats $C_p$ and $C_v$ of gaseous helium in a temperature range which covers the λ-point of liquid helium. The sound velocity of the gas does not show a discontinuity at this point. H.London

4523 EXPERIMENTAL RESEARCH WITH $He^3$. V.P.Peshkov and K.N.Zinov'eva.
Uspekhi. fiz. Nauk (USSR), Vol. 67, No. 1, 193-244 (Feb., 1959). In Russian. English translation in: Soviet Physics—Uspekhi (USA), Vol. 2(67), No. 1, 82-118 (Jan.-Feb., 1959).

Review article, covering Russian and Western contributions under the following headings: Methods of separation of $He^3$ (this includes separation through a superleak and fractional distillation and the thermodynamic properties of $He^3$-$He^4$ solutions); Saturated vapour pressure — critical point; Equation of the state of $He^3$ gas; Thermomolecular pressure differences in $He^3$; Melting and phase transition curve of solid $He^3$; Density of liquid, gaseous and solid $He^3$; Heat of vaporization; Specific heat; Entropy; Magnetic properties; Viscosity; Thermal conductivity; Surface tension; Speed of sound; Compressibility (of liquid); Adsorption; Cryostats with $He^3$; Obtaining low temperatures by crystallization of $He^3$. 110 references. H.London

4524 DIELECTRIC CONSTANT, DENSITY, EXPANSION COEFFICIENT, AND ENTROPY OF LIQUID $He^3$ UNDER PRESSURE BELOW 1°K. D.M.Lee, H.A.Fairbank and E.J.Walker.
Phys. Rev. (USA), Vol. 121, No. 5, 1258-65 (March 1, 1961).

By measuring the resonant frequency of an LC circuit containing a capacitor filled with liquid $He^3$, the dielectric constant of the liquid was measured from 0.14° to 1°K at several pressures from 0.2 to 29.5 atm. From these measurements the density, expansion coefficient at constant pressure, and the change in entropy on compression from saturated vapour pressure to higher pressures were determined. $\alpha_p$ was found to be negative and, hence, $(\partial S/\partial P)_T$ positive for all pressures below a certain temperature which increased

monotonically with pressure, confirming behaviour found by Brewer and Daunt. A minimum in the melting curve of $He^3$ was found at $T = 0.32 \pm 0.01^\circ$ K and $p = 29.1 \pm 0.1$ atm. The results are compared with those obtained by other methods.

4525 MODES OF ATOMIC MOTIONS IN LIQUID HELIUM BY INELASTIC SCATTERING OF NEUTRONS.
D.G.Henshaw and A.D.B.Woods.
Phys. Rev. (USA), Vol. 121, No. 5, 1266–74 (March 1, 1961).

The wavelength distribution of 4.03$_9$A neutrons scattered inelastically by specimens of liquid helium was measured at 30 angles of scattering in the range $10^\circ$ to $140^\circ$. At each angle of scattering there is a discrete peak which shows little broadening, and little if any excess scattering outside this peak. The changes in energy and momentum corresponding to the change in wavelength of the scattered neutrons were calculated for each angle of scattering. The dispersion curve in the liquid is similar in form to that predicted theoretically but there are differences in detail. For momentum changes ($\hbar Q$) in the range $0.26\ A^{-1} \leq Q \leq 0.6\ A^{-1}$, the measurements fall on a straight line which has a slope given by the velocity of sound. The maximum and the minimum of the curves occur at $1.10\ A^{-1}$ and $13.7^\circ$K and at $1.91\ A^{-1}$ and $8.65^\circ$K, respectively. Beyond the minimum the curve starts to rise with a slope equal to or less than the phonon branch and then falls below this, suggesting the possible existence of a second maximum. The relative partial differential cross-section for the production of a single phonon excitation is low at low momenta, has a maximum in the region of $2.0\ A^{-1}$ and then decreases rapidly to low values in the region of $2.68\ A^{-1}$. The position of the maximum may be compared with $2.05\ A^{-1}$ the maximum in the total differential cross-section curve and $1.91\ A^{-1}$ the minimum of the dispersion curve, respectively. The widths and mean energy change of neutrons scattered through $80^\circ$ were measured at 13 temperatures in the range $1.78^\circ$ to $4.21^\circ$K. Scattering at this angle corresponds to the production of excitations at the minimum of the dispersion curve. The mean energy change decreases rapidly from a value of $8.6_5^\circ$K at $1.1^\circ$K to $5.6^\circ$K at the $\lambda$ temperature where there is a marked change in slope and only a much slower decrease above the $\lambda$ temperature to $4.9^\circ$K at 4.2 K. The widths of the spectra increase rapidly from a value of $< 1^\circ$K at $1.1^\circ$K to $11^\circ$K at the $\lambda$ temperature where there is also a marked change in slope and only a much slower increase to about $15^\circ$K at $4.2^\circ$K. The measured widths are compared with theoretically calculated widths.

4526 ANOMALOUS MELTING PROPERTIES OF $He^3$.
R.L.Mills, E.R.Grilly and S.G.Sydoriak.
Ann. Phys. (USA), Vol. 12, No. 1, 41-55 (Jan., 1961).

Measurements on $He^3$ from $0.3^\circ$ to $1.2^\circ$K were made of: the melting pressure; the volume change on melting; and the molar volume, compressibility coefficient, and thermal expansion coefficient of the liquid at melting. Pressures were transmitted by a spring-loaded bellows, and temperatures were controlled by a liquid $He^3$ bath. A minimum in the melting curve was observed at 28.91 atm and $0.330^\circ$K. The thermal expansion coefficient of solid $He^3$ was shown to be negative below a melting temperature of 1.0 and $1.2^\circ$K. The thermal expansion coefficient of solid $He^3$ was shown to be negative below a melting temperature of 1.0 to $1.2^\circ$K. Other anomalies in the PVT melting properties of liquid and solid $He^3$ associated with the melting curve minimum are discussed.

4527 MUTUAL FRICTION IN HELIUM II.
Yu.G.Mamaladze.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 859-60 (Sept., 1960). In Russian.

A possible method is indicated for experimental detection of a component parallel to the axis of revolution in the mutual friction force between the superfluid and normal components of rotating helium II. [English translation in: Soviet Physics—JETP (USA), Vol. 12, No. 3, 595-6 (March, 1961)].

4528 HELIUM II IN ROTATION.
J.D.Reppy, D.Depatie and C.T.Lane.
Phys. Rev. Letters (USA), Vol. 5, No. 12, 541-2 (Dec. 15, 1960).

A bucket of 2.5 cm diameter filled with liquid helium is suspended from a frictionless bearing. Initially at rest, it is given a sudden rotational impulse (~ 0.2 radians/sec) and is then allowed to coast freely. As the liquid assumes the velocity of the bucket, the velocity of the latter decreases with time until a steady value is reached within about 900 sec at $2.63^\circ$K (He I) and about 1400 sec at $1.37^\circ$K (He II). In both cases, at equilibrium, the liquid rotates in a solid body fashion with the same angular velocity which the bucket then possesses. The acceleration of the He II is at first very slow but later similar to that of He I. This is in agreement with current ideas of the creation of vortex lines in a rotating superfluid. The results disagree with the findings of Pellam (Abstr. 19533 of 1960) who observed in rotating He II near the $\lambda$-point a diminished action on a Rayleigh disk suspended inside the liquid at an angle of $45^\circ$ to the direction of rotational flow. H.London

4529 LIMIT OF STABILITY OF CRYSTALLINE HELIUM.
L.E.Radford.
J. chem. Phys. (USA), Vol. 34, No. 1, 182-3 (Jan., 1961).

The mobility of a vacancy in a crystal at the absolute zero of temperature is investigated. In this minimum energy configuration movement of the vacancy to an adjacent lattice site occurs by tunnelling, the rate being determined by an approximation in which the barrier and adjacent potential wells are formed by nearest neighbour interactions only. There is found a critical volume at which the vacancy begins to move rapidly through the barrier. Identifying this increased mobility with the beginning of the melt, a criterion for stability of the crystalline structure is deduced. On applying this criterion to helium at the absolute zero, general agreement with experimental critical volumes is obtained.

## Superconductivity

4530 EXCITONS AND PLASMONS IN SUPERCONDUCTORS.
A.Bardasis and J.R.Schrieffer.
Phys. Rev. (USA), Vol. 121, No. 4, 1050-62 (Feb. 15, 1961).

The Anderson—Rickayzen equations of motion for a superconductor derived within the random-phase approximation (RPA) are used to investigate the collective excitations of superconductors. A spherical harmonic expansion is made of the two-body interaction potential $V(k,k')$ and a spectrum of excitations whose energies lie within the energy gap $2\Delta$ is obtained. These excitations may be characterized by the quantum numbers L and M involved in the potential expansion. For an L-state exciton to exist, the L-wave part of the potential must be attractive at the Fermi surface. Odd-L-excitons have unit spin and may be considered as spin waves. For s-state pairing in the superconducting ground state, the plasmon mode corresponds to the $L = 0$ exciton whose energy is strongly modified by the long-range Coulomb interaction. For a general potential several bound states may exist for given L and M. If the L-wave potential is stronger than the s-wave part of the potential, the system is unstable with respect to formation of L-state excitons. In this case, the ground state is formed with L-state pairing, special cases of which are the p-state pairing considered by Gisher and the d-state pairing proposed recently by several authors for the ground state of $He^3$ and nuclear matter. Corrections to the Anderson—Rickayzen equations are discussed which lead to a new set of exciton states if the L-wave potential is repulsive. These excitons are interpreted as bound electron—hole pairs, as opposed to the particle—particle excitons present with an attractive L-wave potential.

4531 DIAMAGNETISM OF MANY-FERMION SYSTEMS.
G.L.Sewell.
Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 136-46 (Jan., 1961).

A set of simple theoretical criteria is established for the occurrence of the Meissner effect in a many-electron system. The criteria are of a qualitative nature and involve only the single- and two-particle excitations of the system.

4532 A METHOD OF APPROXIMATE SECOND QUANTIZATION IN THE THEORY OF SUPERCONDUCTIVITY.
Z.Galasiewicz.
Progr. theor. Phys. (Japan), Vol. 23, No. 3, 197-217 (Feb., 1960).

The Hamiltonian of a dynamical system of Fermi-particles is transformed by means of the general unitary transformation proposed by Bogolyubov (Abstr. 2714 of 1961). From this Hamiltonian the approximate second quantization Hamiltonian is obtained, introducing the Bose amplitudes with two indices. This Hamiltonian is diagonalized and the collective oscillations considered, especially for the pairs of particles with parallel spins. For the forced collective oscillations the paramagnetic term in the Hamiltonian is also taken into account. This term leads to the additional "spin" current, connected

th the elementary excitations with spin moment ± 1. If the transfer omentum tends to zero, this current vanishes as the terms omitted in taining the Meissner-Ochsenfeld effect.

4533 SUPERCONDUCTING TRANSITION IN ZINC AND GALLIUM. J.F.Cochran and D.E.Mapother.
hys. Rev. (USA), Vol. 121, No. 6, 1688-92 (March 15, 1961).

These transitions were studied to compare the supercooling of a and Zn with that shown by Al under similar conditions. Both Ga nd Zn show considerably less tendency to supercool than Al despite eir lower critical temperatures. The measurements also provide lues of $T_c$ and $(dH_c/dT)_{T_c}$ for Ga and Zn for comparison with cently reported calorimetric data. Attention is called to the fact at discrepancies still exist between direct calorimetric determina- on of the specific heat discontinuity at the critical temperature and e value deduced thermodynamically from critical field data. It is own that such discrepancies are conspicuously worse among the ements Zn, Ga, and Al than for the elements of higher $T_c$ (In, Sn, a, and Pb) where agreement is within experimental error.

BOSE–EINSTEIN CONDENSATION OF CORRELATED PAIRS. PPLICATION IN THE THEORY OF SUPERCONDUCTIVITY. ee Abstr. 4278

MAGNETIC MOMENT OF TRANSITION METAL ATOMS IN ILUTE SOLUTION AND THEIR EFFECT ON SUPERCONDUCTING RANSITION TEMPERATURE. See Abstr. 3882

# ELECTRICITY
# ELECTRICAL MEASUREMENTS AND CIRCUITS

4534 HIGHLY STABILIZED AND SENSITIVE REACTANCE METER. B.Ichijo and T.Arai.
Rev. sci. Instrum. (USA), Vol. 32, No. 2,122-30 (Feb., 1961).

Presents an explorative circuit system functioning as a highly tabilized and sensitive reactance meter with a wide range of appli- ation in various fields of scientific research and industrial opera- ion. With a measuring range of $10^{-3}$ to $10^{+6}$pF, it has a sensitivity f 5-10 μA/0.001 pF when measured through an ammeter with a full cale of 100 μA, and a stability of less than 1 μA in terms of zero rift during several hours. Some experimental data are given for he appreciation of its characteristics.

4535 ELECTRICAL CONDUCTANCE CELL ASSEMBLY FOR PRECISE MEASUREMENTS WITH CARBONATES, OXIDES, AND FLUORIDES UP TO 1000° C.
J.J.Janz and M.R.Lorenz.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 130-3 (Feb., 1961).

A conductance cell assembly is described of the capillary lesign with a cell constant sufficiently high to permit precise lectrical conductance measurements with the standard-type recision conductance bridge circuits. Important features are he use of single crystal grade MgO for construction of the capil- aries that determine the resistance for the electrolyte in the con- luctance cell, and the use of such materials as gold, or gold– alladium alloy to construct the various other components of the ell that contact the molten salts. The suspension of the MgO rystal capillaries is of a novel design which permits removal f the capillaries from the assembly for inspection or cleaning, nd yet holds these firmly and securely in position during mea- urements. It is shown that recently published values of electrical onductance for molten KCl and $KNO_3$ may be used as standards or calibration of such cells at high temperatures.

4536 DEFINITIONS OF RESONANCE AND EXACT CONDITIONS FOR RESONANCE IN SOME ELECTRICAL CIRCUITS. II. TUNED COUPLED CIRCUITS. E.J.Burge.
Amer. J. Phys., Vol. 29, No. 4, 251-6 (April, 1961).

For Pt I, see Abstr. 261 of 1961. The theory for simple tuned oupled circuits is given and exact conditions for some definitions f resonance are found and discussed. Approximations for high Q ircuits are also compared.

4537 NOISE FIGURE AND GAIN OF PARAMETRIC CONVERTORS. H.Heffner and G.Wade.
J. appl. Phys. (USA), Vol. 31, No. 12, 2316 (Dec., 1960).

Some errors and misprints in the noise figure equation (Abstr. 8940 of 1958) are corrected and it is pointed out that the analysis there given can also be applied to the nonregenerative convertor. A.H.W.Beck

4538 HIGH CURRENT ELECTRONIC POTENTIOSTAT. D.N.Staicopoulos.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 176-8 (Feb., 1961).

The design of a high-current transistorized potentiostat capable of delivering currents of the order of 5 A for anodic or cathodic polarization studies at controlled potentials is presented. The range of potentials possible is determined only by the characteristics of the test electrode/solution interface. The response of this instrument is such that switching from maximum cathodic to maximum anodic potentials and vice versa can be accomplished within $10^{-3}$ sec. Analysis indicates that it is possible to effect a tenfold increase in the current-carrying capacity of this potentiostat with only minor modifications. The combination of high speed, short rise-time, and high current instantly available for either anodic or cathodic polarization is unique in this potentiostat and provides outstanding versatility.

SENSITIVE OUTPUT INDICATOR FOR DIFFERENTIAL TRANSFORMER DISPLACEMENT DETERMINATIONS. See Abstr. 4294

30 kW, 500 μSEC VACUUM-TUBE PULSER. See Abstr. 4588

4539 A WIDE PULSE HEIGHT DYNAMIC RANGE COINCIDENCE CIRCUIT FOR SLOW PHOSPHORS.
R.J.A.Levesque and W.F.Hornyak.
Nuclear Electronics Conference, Paris, 1958. Vol. I. (see Abstr. 12719 of 1960) p. 287-90.

Two trigger circuits, each comprising a cathode follower and a secondary emission valve, accept positive signals from the photomultiplier dynodes. The coincidence circuit consists of pulse shaping delay lines and a diode discriminator. Series diodes clamp the discriminator to whichever of the inputs is the smaller. The time resolution is of the order of 20 mμsec. W.G.Stripp

4540 HALF-LIFE MEASUREMENT IN THE MICRO- AND MILLISECOND RANGE. M.S.Malkin.
Nuclear Electronics Conference, Paris, 1958, Vol. I (see Abstr. 12719 of 1960) p. 307-9.

The arrangement described was devised to measure the half-lives of secondary activities excited by bombardment of a target in a pulsed accelerator. At the start of the accelerator-beam pulse a detector is blocked; it is released at the end of the pulse and a sawtooth generator is triggered. The detector pulses, shaped by a blocking oscillator, and the sawtooth voltage are applied to a diode linear-gate, and the gate output is passed to a 20-channel height analyser. W.G.Stripp

4541 20-CHANNEL TIME ANALYSER FOR SELECTING FAST NEUTRONS BY THEIR TIME OF FLIGHT.
A.I.Veretennikov and V.Ya.Averchenkov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 48-53 (May-June). In Russian.

The analyser is based on the time-to-amplitude conversion principle. The practical resolution time is 1.5 to 3 mμsec; the electrical resolution time is 0.45 mμsec; the instability of the channel boundaries is 0.5 mμsec. The performance is illustrated by data on neutron selection from a Po–Be–source. [English translation in: Instrum. exper. Tech. (USA), No. 3, 371-6 (May-June, 1958; publ. June, 1959)].

4542 SIMPLE AMPLIFIER AND PULSE-HEIGHT ANALYSER FOR AN X-RAY SCINTILLATION COUNTER. B.B.Trott.
J. sci. Instrum. (GB), Vol. 38, No. 3, 74-7 (March, 1961).

A simple circuit, using only four valves, was developed to serve as amplifier and pulse-height analyser for an X-ray scintillation counter. Results obtained suggest that large noise pulses in the photomultiplier may be caused by repeated optical feedback.

4543 A HIGH-SPEED AMPLITUDE ANALYSER WITH A "GREY WEDGE". O.B.Likin.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 36-40 (March-April). In Russian.

The construction is described of a high-speed pulse-height analyser which is based on a photographic method of recording the spectra using a "grey wedge". The instrument is equivalent to a 50-channel analyser in amplitude resolution. The accuracy of the determination of the number of pulses recorded is not less than 6%. The resolving time of the instrument is 3 $\mu$sec. Photographic materials and their processing are recommended. [English translation in: Instrum. exper. Tech. (USA), No. 2, 213-17 (March-April, 1958; publ. April, 1959)].

4544 LOW-LEVEL LINEAR MICROSECOND GATE. P.R.Chagnon.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 68-70 (Jan., 1961).

A linear transmission gate for use in scintillation counter coincidence experiments is described. The gate is suitable for negative pulses of microsecond duration and is linear over a range from 0.01 to 5 V. The circuit is relatively simple, uses no vacuum tubes, and is reliable over long periods of use. The use of low-level gates can increase the usable counting rate of a multichannel coincidence system by an order of magnitude.

4545 TRANSIENTS IN LOGARITHMIC COUNT-RATE AND PERIOD METERS. B.B.Barrow and R.Maitland.
Trans Amer. Inst. Elect. Engrs I, Vol. 79, 362-9 (1960) = Commun. and Electronics, No. 50 (Sept., 1960).

Considers the problem of measuring neutron flux transients at low levels using a logarithmic rate-meter. The problem is to get good differentiation at low frequencies and to reduce noise at high frequencies. An analysis shows that a good design compromise is possible. The results were tested experimentally on a reactor simulator and found to be in accord with theory.

A.E.I. Research Laboratory

4546 REVIEW OF THE PRINCIPLES OF REGISTRATION USED IN MULTICHANNEL PULSE-HEIGHT AND TIME ANALYSERS. G.P.Mel'nikov.
Uspekhi fiz. Nauk (USSR), Vol. 68, No. 1, 179-84 (May, 1959). In Russian. English translation in: Soviet Physics—Uspekhi (USA), Vol. 2(68), No. 3, 465-8 (May-June, 1959).

Compares critically the following types of multichannel analyser: (1) independent registering devices in each channel; (2) ferrite memory elements in each channel; (3) Hutchinson–Scarrot type, using a mercury delay line and its variants (quartz delay line, magnetic drum or cathode-ray tube); (4) electrostatic memory tube as the memory device. Brief mention is also made of continuously operating registers (recorders, photoregisters, etc.).

I.C.Demetsopoullos

4547 A 100 dB MICROWAVE SEMICONDUCTOR SWITCH. D.W.Feldman and B.R.McAvoy.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 74-6 (Jan., 1961).

The dual-diode switch provides more than 100 dB switched attenuation with low insertion loss. Switching time of the device, limited by the diodes, is $3 \times 10^{-7}$ sec. Application of the switch in a 9000 Mc/s superheterodyne magnetic resonance spectrometer as a mixer crystal protector and as a microwave signal blanker is described.

# ELECTROSTATICS . DIELECTRICS

*(The study of solids through their dielectric properties is included under Solid-State Physics; similarly for Liquid State and Gaseous State)*

4548 INVESTIGATION OF FINITE DIFFERENCE EQUATIONS FOR POINTS ON A SURFACE CHARGE DISTRIBUTION. J.Gilard.
C.R. Acad. Sci. (France), Vol. 251, No. 25, 2906-8 (Dec. 19, 1960). In French.

4549 STATIC ELECTRIFICATION OF FILAMENTS: EFFECT OF FILAMENT DIAMETER. D.J.Montgomery, A.E.Smith and E.H.Wintermute.
Textile res. J. (USA), Vol. 31, No. 1, 25-31 (Jan., 1961).

A study was made of the effect of filament diameter on the charge transferred between filaments rubbed together under controlled ambient and mechanical conditions. Filaments of various diameters and of medium resistivity (nylon, $\sim 10^{12}$ ohm cm) were rubbed against a filament of low resistivity (tantalum, $\sim 10^{-5}$ ohm cm and one of high resistivity (polyethylene, $\sim 10^{15}$ ohm cm) at different normal forces between the filaments. For nylon against tantalum, the charge transferred was found to be proportional to the square root of the product of the diameter and the normal force between the filaments. For nylon against polyethylene, the charge transferred was found to be proportional to the square root of the normal force, but nearly independent of the diameter. These findings are consistent with the hypothesis that the charge transferred is proportional to the true area of contact (that is, the area over which interpretation of molecular fields occurs) swept out on the object of lower conductivity.

4550 ON THE CAPACITY OF THE ICOSAHEDRON. J.Conlan, J.B.Diaz and W.E.Parr.
J. math. Phys. (USA), Vol. 2, No. 2, 259-61 (March-April, 1961).

An application of Dirichlet's principle, using a simple trial function suggested by the symmetries of the problem, is shown to furnish fairly close, readily computable, upper bounds for the capacitance of any regular solid.

# CURRENT ELECTRICITY ELECTROKINETICS

*(The study of solids through their electrical conduction properties is included under Solid-State Physics)*

4551 UNIFORMITY OF ELECTRICAL CURRENT FLOW IN CYLINDRICAL SEMICONDUCTOR SPECIMENS WITH CYLINDRICAL METALLIC END CAPS.
R.Simon, J.H.Cahn and J.C.Bell.
J. appl. Phys. (USA), Vol. 32, No. 1, 46-7 (Jan., 1961).

The distribution of current is computed in specimens with end caps of the same diameter as that of the specimen and electrical lead wires of much smaller diameter. Nonuniformity of the longitudinal current density of 1% or less can be obtained in specimens with electrical resistivities at least 200 times greater than that of the end caps if the lengths of the specimens are at least equal to their diameters and if the length of each end cap is at least 0.3 diam.

4552 ELECTROKINETIC POTENTIAL (EKP) VERSUS ELECTROMOTIVE FORCE (EMF). S.S.Major, Jr.
Amer. J. Phys., Vol. 28, No. 9, 816 (Dec., 1960).

A case is made for the adoption of the term electrokinetic potential for the property of a circuit element which is usually referred to as the electromotive force. [The treatment is too brief to clarify effectively this difficult concept.] E.G.Knowles

# IONIZATION

4553 ELECTRON AVALANCHES AND THEIR DEVELOPMENT. H.Raether.
Ergeb. exakt. Naturwiss. (Germany), Vol. 33, 67 pp. (1961). In German.

Review article. Investigations of single avalanches; Properties of electron avalanches; Electron avalanches with subsequent phenomena; Electron avalanches initiated by a large number of primary electrons; Development of the electron avalanche to breakdown: Generation build-up; Canal build-up; Results on the canal build-up; Applications (parallel-plate counter, discharge camera).

4554 THE FRANCK–CONDON PRINCIPLE AND THE IONIZATION AND DISSOCIATION OF HYDROGEN BY ELECTRON IMPACT. D.P.Stevenson.
J. Amer. Chem. Soc., Vol. 82, No. 23, 5961-6 (Dec. 5, 1960).

Various old and new data on the ionization and dissociation of

rdrogen and deuterium by single electron impact are reviewed. is shown that neither the average appearance potentials of $H_2^+$ and $H_3^+$, nor the distribution in kinetic energy of the protons or deuterons e those expected from the conventional application of the Franck–ondon principle to the potential energy diagrams of hydrogen and s molecule-ions. The experimental findings can be rationalized ith the presumably accurately known potential energy curve inform- ion on the hypothesis that 15 to 100 V electrons can form transient mplexes with hydrogen molecules [$H_2^-$], with lives in the range $^{-14}$ to $10^{-13}$ sec.

4555 IONIZATION CROSS SECTIONS FOR PROTONS ON HYDROGEN GAS IN THE ENERGY RANGE 0.15 TO .10 MeV.
.W.Hooper, E.W.McDaniel, D.W.Martin and D.S.Harmer.
hys. Rev. (USA), Vol. 121, No. 4, 1123-7 (Feb. 15, 1961).

The experimental cross-sections in this region can be repre- ented by

$$\sigma_i = (3.45 \pm 0.20)\, E^{-(0.874 \pm 0.010)} \times 10^{-17} \text{ cm}^2/\text{molecule},$$

here E is the incident proton energy in MeV. The experimental esults are in excellent agreement with a Born approximation alculation, which is discussed.

4556 IONIZATION OF LITHIUM BY FAST PROTONS AND ELECTRONS. M.R.C.McDowell and G.Peach.
hys. Rev. (USA), Vol. 121, No. 5, 1383-7 (March 1, 1961).

Born's approximation is used to calculate the cross-sections r ionization of lithium by fast protons (< 1 MeV) and electrons < 1 keV). The electron impact results are in good agreement with ose obtained by Seaton's method (Abstr. 5847 of 1959) from experi- ental photoionization data. The maximum cross-section for proton mpact is $1.1\pi a_0^2$ at 20 keV.

4557 IONIZATION IN COLLISIONS BETWEEN IONS AND ATOMS. N.V.Fedorenko.
spekhi fiz. Nauk (USSR), Vol. 68, No. 3, 481-511 (July, 1959). In ussian. English translation in: Soviet Physics–Uspekhi (USA), ol. 2(68), No. 4, 526-46 (July-Aug., 1959).

Review of recent experimental results using incident energies ss than 1 MeV, and comparison with theoretical predictions. The ain topics covered are: total ionization cross-section, ionization ith formation of multiply-charged ions, and the angular distribu- on of scattered particles in ionization collisions. 68 references.
J.Hawgood

4558 THE COMPOSITION OF SLOW IONS PRODUCED DURING IONIZATION OF GASES BY NEGATIVE IONS.
a.M.Fogel', A.G.Koval', Yu.Z.Levchenko and A.F.Khodyachikh.
h. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 548-55 (Sept., 1960). Russian.

The composition of slow ions produced by 10 to 50 keV $H^-$ and $O^-$ ns in He, Ne, A, Kr, Xe, $H_2$, $N_2$ and $O_2$ was analysed with a mass ectrometer. The data of the present investigation and of an rlier study of positive ion formation, were used to calculate cross- ections for ionization involving detachment of a definite number of ectrons from an atom. The effective cross-sections for production slow ions with various charges by $H^-$ and $H^+$ ions were compared. English translation in: Soviet Physics–JETP (USA), Vol. 12, No. 3, 54-9 (March, 1961)].

4559 THE LIFETIME OF THE $He^-$ ION.
D.R.Sweetman.
roc. Phys. Soc. (GB), Vol. 76, Pt 6, 998-1000 (Dec., 1960).

$He^-$ ions, produced by collisions of 1 MeV $He^+$ ions with low ressure air, were passed through a 60 cm long evacuated drift ube, analysed magnetically on emergence, and counted with a CsI rystal counter; the fraction of $He^-$ decaying to $He^0$ was thus easured. Ignoring dissociative processes at beam stops and with esidual gas, and assuming the production of $He^0$ to be a result of e natural decay of $He^-$ only, a minimum lifetime of the $He^-$ state $1.0 \times 10^{-6}$ sec was deduced. The cross-section for the reaction $e^- \rightarrow He^0$, on interaction of the negative ion with helium gas, was easured by inserting a variable pressure helium gas cell in the rift path; the value determined was $(2.13 \pm 0.20) \times 10^{-16}$ cm$^2$ per olecule at 1.09 MeV energy.
G.Carter

4560 ENERGY DISTRIBUTION OF ELECTRONS FROM IONIZING COLLISIONS OF HEAVY PARTICLES.
H.W.Berry.
Phys. Rev. (USA), Vol. 121, No. 6, 1714-19 (March 15, 1961).

The energy distribution of electrons produced in ionizing collisions of ions and fast atoms with atoms of the parent gas at rest has been measured for A and He. The energy of the incident particles ranged from 0.30 to 3.0 keV. Electrons released at 90° with the incident ion or atom beam were analysed in an electrostatic energy selector which consisted of 90° segments of coaxial cylinders. The use of a fine wire grid in the region in which the ionization occurred allowed a positive differentiation to be made between the ionization electrons and the secondary electrons from any metal surfaces. The electron distributions for argon ions and atoms in argon are similar and show a rapid decrease in the yield as the energy increases from zero to about 4 eV followed by a plateau and a flat maximum near 12 eV. The distributions for He also show the initial rapid decrease continuting to a small maximum which for the ion is at about 31 eV and for the neutral atom at about 16 eV. These distributions are almost collision energy independent, though with an increase in the overall yield with increasing energy.

DETERMINATION OF ELECTRON VELOCITY DISTRIBUTION IN IONIZED GASES FROM BREMSSTRAHLUNG EMISSION. See Abstr. 3163

4561 ON THE FLOW AND EXCHANGE DIFFUSION OF ELECTRONS AND NEGATIVE IONS FORMED BY MOLECULAR ATTACHMENT. W.G.Kauman.
Austral. J. Phys., Vol. 13, No. 2, 193-6 (June, 1960).

Theoretical expressions are obtained for the structure of a stream of electrons and negative ions diffusing and drifting in an electric field in a gas in which processes of attachment and detachment are occurring; the expressions relate to steady and non-steady states, d.c. and a.c. fields and various boundary conditions.
J.Dutton

4562 ELECTRON TEMPERATURE DEPENDENCE OF THE RECOMBINATION COEFFICIENT IN PURE HELIUM.
C.L.Chen, C.C.Leiby and L.Goldstein.
Phys. Rev. (USA), Vol. 121, No. 5, 1391-1400 (March 1, 1961).

The phenomenon of "afterglow quenching" is employed to determine the electron temperature dependence of the electron–ion recombination coefficient in plasmas produced in purified helium (estimated impurity 1 : $10^9$). The total visible light intensity was studied as a function of electron temperature. By means of 1.5% bandwidth filters, the light intensities of two helium spectral lines (5876 and 3888 A) were also investigated. It is found that the recombination coefficient for highly purified helium varies as (electron temperature)$^{-3/2}$ from 300° to ~ 1500° K at electron densities of ~ $10^{11}$ cm$^{-3}$, and gas pressures from 12.6 to 30.3 mm Hg. At 300° K (temperature determined from collision frequency measurements), the recombination coefficient in purified helium is found to be $(8.9 \pm 0.5) \times 10^{-9}$ cm$^3$/ion sec. It is found that both the recombination coefficient and its electron temperature dependence were strongly influenced by the addition of controlled amounts ($2 \times 10^{-4}$ to $1300 \times 10^{-4}$ %) of neon impurities.

4563 CHARGE EXCHANGE BETWEEN ARGON IONS AND ATOMS. S.B.Karmohapatro.
Proc. Phys. Soc. (GB), Vol. 76, Pt 3, 416-19 (Sept., 1960).

The method of Abstr. 7135 of 1958 is used to calculate the cross-section for this process. The experimental results of Abstr. 5429 of 1957 are quite well reproduced when a Löwdin–Appel analytic wave-function is used.
J.Hawgood

4564 DISSOCIATION AND CHARGE EXCHANGE OF HYDROGEN AND DEUTERIUM MOLECULAR IONS BY PASSING THROUGH HYDROGEN. A.Schmid.
Z. Phys. (Germany), Vol. 161, No. 5, 550-9 (1961). In German.

In a beam of $H_2^+$ or $D_2^+$ ions passing through hydrogen, the following secondary particles are produced by dissociation and charge exchange: $H^+$, $H^0$, and $H_2^0$ ($D^+$, $D^0$, and $D_2^0$, respectively). The cross-sections $q_1$, $q_2$, and $q_3$ for the production of these particles were measured in the energy range from 15 to 95 keV. A proportional counter supplemented by an electrostatic field at its immediate entrance was used for detecting and discriminating the different particles.

4565 CHARGE TRANSFER MEASUREMENTS ON Li IONS IN THE ENERGY RANGE FROM 3 TO 10 keV. K.Bethge.
Z. Phys. (Germany), Vol. 162, No. 1, 34-45 (1961). In German.

An ion source is described where a beam of lithium ions is directly emitted from a platinum filament coated with the lithium mineral β-eucryptite. Charge exchange cross-sections were measured for the gases A, $N_2$, $N_2O$, $H_2$, $O_2$, $CH_4$, $CCl_2F_2$ and air. The results in this energy range agree with the adiabatic hypothesis of Massey. The uncharged particles were detected by means of a secondary electron emission detector. The secondary electron emission yield for a Cu–Be and a Ag–Mg surface by bombardment with lithium ions was measured.

4566 RESONANCE CHARGE TRANSFER IN THE CASE OF POSITIVE POTASSIUM IONS.
D.V.Chkuaseli, U.D.Nikoleishvili and A.I.Guldamashvili.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 817-23 (July, 1960). In Russian.

For abstract, see Abstr. 278 of 1961. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 770-6 (Jan., 1961)].

4567 SURFACE IONIZATION.
É.Ya.Zanberg and N.I.Ionov.
Uspekhi. fiz. Nauk (USSR), Vol. 67, No. 4, 581-623 (April, 1959). In Russian. English translation in: Soviet Physics–Uspekhi (USA), Vol. 67(2), No. 2, 255-81 (March-April, 1959).

A critical review of theoretical and experimental studies of the formation of positive and negative ions on the surface of metals and semiconductors from which atoms or molecules are evaporating. Consideration is given to the emission of ions from both homogeneous and inhomogeneous surfaces in the presence, and in the absence, of electric fields. 113 references. J.Dutton

4568 SURFACE IONIZATION OF ATOMS OF INDIUM AND THALLIUM ON POLYCRYSTALLINE TUNGSTEN WITH ELECTRIC FIELDS UP TO 2 MV/cm. É.Ya.Zandberg.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1215-21 (Oct., 1960). In Russian.

Refers to previous investigations by the author into the ionization of sodium and lithium atoms on polycrystalline tungsten using applied fields of 1.3 MV/cm in a cylindrical electrode system. This work is now extended to indium and thallium atoms, using fields up to 2.1 MV/cm and temperatures from 1900 to 2500°K. The course of the experiment was controlled by a built-in mass spectrometer. The experimental observations are in good agreement with the values given by a theory taking into account the inhomogeneity of the local work function. As a by-product of the experiments an estimate was obtained for the greatest local value of the work function of polycrystalline tungsten. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 10, 1152-7 (April, 1961)]. A.E.I. Research Laboratory

4569 SURFACE IONIZATION OF CAESIUM ON DIFFUSION THROUGH POROUS TUNGSTEN.
Yu.Ya.Stavisskii and S.Ya.Lebedev.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1221-6 (Oct., 1960). In Russian.

Caesium deposited on the surface of tungsten is found to be highly ionized even when the temperature is so great that no adsorbed caesium layer can occur. In order to aid understanding of this, the ionic current was measured and its dependence on the temperature of the emitter and applied voltage was determined. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 10, 1158-61 (April, 1961)]. A.E.I.Research Laboratory

# ELECTRIC DISCHARGES

4570 GENERAL ASPECTS OF THE ELECTROMAGNETIC PHENOMENA OF DISCHARGE IN GASES.
L.Goldstein and R.Musson-Genon.
Vide (France), Vol. 14, 327-43 (Nov.-Dec., 1959). In French.

A mainly theoretical survey of the properties of an incompletely ionized gas under the influence of high-frequency electromagnetic fields, with special reference the phenomena occurring in radar switches. J.Dutton

4571 THE DISTRIBUTION FUNCTION OF ELECTRONS BY THEIR VELOCITIES IN THE POSITIVE COLUMN OF A MEDIUM-PRESSURE DISCHARGE.
Yu.M.Kagan and K.S.Mustafin.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 938-47 (Aug., 1960). In Russian.

For abstract, see Abstr. 16981 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 8, 881-9 (Feb., 1961)].

4572 INVESTIGATION OF THE PERFORMANCE OF CONTROLLED SPARK GAPS IN AIR. P.I.Shkuropat.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 954-63 (Aug., 1960). In Russian.

For abstract, see Abstr. 282 of 1961. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 8, 895-902 (Feb., 1961)].

4573 THE FIRING OF GAS DISCHARGE DEVICES.
T.A.Sanina, A.A.Sanin and N.R.Fedorenkova.
Pribory i Tekh. Eksper (USSR), 1958, No. 1, 116-19 (Jan.-Feb.). In Russian.

The investigation was concerned with the relationship between the delay in firing and a number of factors, such as the voltage ripple, frequency of repeated firing,etc. By means of a photomultiplier, the charge concentration during the deionization period was studied. [English translation in: Instrum. exper. Tech. (USA), No. 1, 129-32 (Jan.-Feb., 1958; publ. April, 1959)].

4574 FULL-VOLTAGE RANGE SPARK-GAP CROWBAR.
E.M.Goldfarb and H.G.Heard.
J. appl. Phys. (USA), Vol. 32, No. 2, 326 (Feb., 1961).

A new three-ball spark-gap configuration and three modes in which this spark-gap operates are described. This arrangement eliminates the voltage restriction of trigger gaps and permits their extension to full-voltage operation for very high voltages. This may find application not only as a crowbar in controlled fusion reaction, but also for generating high voltage pulses. B.Chaudhuri

4575 SOME PROPERTIES OF HIGH-FREQUENCY CORONA RADIATION DISCHARGE.
N.B.Bogdanova and V.I.Popkov.
Dokl. Akad. Nauk SSSR, Vol. 134, No. 6, 1331-3 (Oct. 21, 1960). In Russian.

The electric corona is photographed and its high-frequency radiation detected simultaneously. The change in form of the discharge as applied voltage increases is described. It is found that far more radiation occurs during the positive half-period than during the negative. [English translation in: Soviet Physics–Doklady (USA)]. A.E.I. Research Laboratory

4576 AFTERGLOW AND ITS RELATIONSHIP WITH THE GAS DENSITY IN A PULSE DISCHARGE IN NEON.
V.S.Egorov and A.M.Shukhtin.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 794-6 (Dec., 1960). In Russian.

Increase in the number of excited atoms at the end of a short current pulse (16-200 μsec duration and up to 100 A/cm² amplitude) in neon at 1-4 mm Hg is explained by a rise of the gas density on the discharge axis at the end of the pulse. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

4577 THE CONNECTION BETWEEN STATIC AND MOVING STRIAE IN THE POSITIVE COLUMNS OF GLOW DISCHARGES. S.Pfau and A.Rutscher.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 244-51 (1960). In German.

Experimental evidence is given for the basic similarity of stationary and moving striae in glow discharges operating in low pressure molecular gases. The wavelength, amplification and group velocities correspond well in both cases. Rotating-mirror photographs of the initiation of, or of a temporary disturbance in, the discharge show that both forms of striae can transform one into the other. By using an external transverse magnetic field, the amplification of moving striae can be appreciably increased. H.Edels

4578 ELECTRICAL OSCILLATIONS IN A D.C. GLOW DISCHARGE. V.T.Chiplonkar and J.Mangaly.
oc. Indian Acad. Sci. A, Vol. 49, No. 5, 262-80 (1959).
Oscillations in a hydrogen d.c. glow were investigated. The scharge was operated in the region of the positive V–I characteristic in the pressure range 40-200 μ at currents from 0.1 to 2.5 mA. herent oscillations in the l.f. range from 40 to 100 kc/s were served and a group of oscillations in the higher range from 170 to 00 kc/s accompanied the lower frequencies. It is shown that a mmon cut-off current exists for all the frequencies and the pendence upon pressure of this current is given. The dependence the frequencies and amplitudes on current and pressure is also ven. The cathode dark space and the variation of amplitude of cillation with distance from the cathode are considered. The periments show that the different frequencies are related to each her but do not arise out of a single common mechanism. The seat the oscillations appears to be in the region of the negative glow.
H.Edels

4579 DEPENDENCE OF SILENT DISCHARGES ON EXTERNAL PRESSURE. P.S.V.Setty.
sci. industr. Res. (India), Vol. 19B, No. 3, 112-13 (March, 1960).
An inner discharge tube filled with iodine vapour was enclosed a coaxial glass enclosure which could be maintained at a desired essure. Experiments show that the discharge current decreases th increasing pressure in the enclosure. Irradiation of the discharge by white light produces a current effect which is also affected the enclosure pressure. The results are explicable if the discharge is of an electrostatic type, the pressure in the enclosure fecting the adsorbed vapours in the glass and hence the dielectric lue of the glass.
H.Edels

4580 THE FALLING CURRENT–POTENTIAL CHARACTERISTIC UNDER THE SILENT ELECTRIC DISCHARGE. THE INFLUENCE OF DIFFERENT DETECTORS.
P.Jatar and H.D.Sharma.
oc. Nat. Acad. Sci. India A, Vol. 28, Pt 5, 229-35 (1959).
The current–voltage characteristics of low-frequency (50 c/s) scharges in air in Siemens type glass ozonizers were measured ing various types of current detector. The falling part of the aracteristic was found to be coincident with the disappearance of lses from the current trace obtained on an oscillograph. The sults are discussed briefly in terms of space charge development.
J.Dutton

4581 PROBING THE POSITIVE COLUMN OF A LOW-CURRENT DISCHARGE IN NEON. H.Rothman.
ud. Cercetari Fiz. (Roumania), Vol. 8, No. 3, 255-66 (1957). In umanian.
Measurements carried out in the positive column of a Ne discharge in a tube of interior diameter 24 mm, at a pressure of about mm Hg and with currents of 1.5 and 23 mA, have lead to semigarithmic characteristics for the probe of parabolic form. If the obe current is calculated on the assumption that the distribution in e plasma is of the Druyvesteyn–Davydov type, one concludes that e semilogarithmic characteristic should be to a first approximation similar to the form obtained in the present experiment. From is it is concluded that, under the conditions of the experiment nen the effective cross-section is practically independent of the ectron velocity, the distribution of velocities is that given by the ruyvesteyn–Davydov distribution. From the semilogarithmic probe aracteristic the number of carriers of electricity per $cm^3$ was lculated. Also using the method of least squares, the constants and $C_2$ of the parabola were calculated for differing experimental nditions. These values are tabulated and graphs are plotted of g I as a function of the probe potential for a number of cases.
W.G.Townsend

4582 ON THE QUESTION OF THERMAL EQUILIBRIUM IN THE IRON ARC. K.H.Krysmanski.
nn. Phys. (Germany), Vol. 6, No. 3-4, 169-76 (1960). In German.
Using known values of transition probabilities (not obtained om arc studies) and measured values of line intensities, temperares of iron arcs (2 to 200 A) are calculated on the assumption that ermal equilibrium does not exist. The values are in general lower an those previously obtained on the assumption of thermal equilibium, the differences being greater the lower the current. It is ncluded that the higher the current the more nearly is thermal uilibrium attained.
J.Dutton

4583 NOTE ON A PINCH EFFECT IN A LOW PRESSURE ARC. A.R.Johnston and K.G.Emeleus.
Proc. Phys. Soc. (GB), Vol. 76, Pt 3, 409-16 (Sept., 1960).
An insulated central conductor was placed in a hot cathode, ~100 mA, mercury vapour discharge at 1-2 μ Hg pressure in a tube 60 cm long by 5 cm in diameter. Currents of up to 150 A were passed through the conductor, generating an azimuthal magnetic field. Measurements with Langmuir probes are reported, together with qualitative observations.
R.S.Pease

4584 PHENOMENA OF INTERNAL INSTABILITY OF AN ARC WITH A MERCURY CATHODE. II. NON-STATIONARY PROCESSES IN THE CATHODE REGION OF THE ARC. III. BREAK-UP AND RE-FORMATION OF THE CATHODE SPOT IN CONDITIONS OF STATIONARY ARC. I.G.Kesaev.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 6, 674-84 (June); No. 7, 803-14 (June, 1960). In Russian.
For Pt I, see Abstr. 16989 of 1960. The spontaneous extinction of a low-pressure arc with a mercury cathode is linked with voltage oscillations on the electrodes and unstable behaviour near the cathode. The latter is manifested in instabilities of the cathode spot, which, consisting of an aggregate of elementary cells, continually forms and reforms, upheld by random oscillations due to breaks in the normal arcing cycle. An extinguished arc tends to reform thanks to a starting mechanism, the efficiency of which increases with rising current. [English translation in: Soviet Physics–JETP (USA), Vol. 5, No. 6, 635-42 (Dec., 1960)].
A.E.I. Research Laboratory

4585 DEPENDENCE OF THE [ELECTRIC] ARC STABILITY ON THE STATE OF THE CATHODE.
I.G.Kesaev and L.A.Levshenkova.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 815-16 (July, 1960).
In Russian.
For abstract, see Abstr. 16987 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 768-9 (Jan., 1961)].

4586 THE INITIATION OF ELECTRICAL BREAKDOWN IN VACUUM. W.E.Meyer.
Z. angew. Phys. (Germany), Vol. 13, No. 1, 51-2 (Jan., 1961). In German.
Consideration is given to the mechanism of electric breakdown in high vacuum ($p < 10^{-3}$ mm Hg). Theory indicates that a model proposed by Cranberg is correct. In this case, the electrical energy is transformed into heat at the electrodes, producing vaporization and consequent spark breakdown.
H.Edels

ELECTRON AVALANCHES AND THEIR DEVELOPMENT.
See Abstr. 4553

4587 ELECTRON-ENERGY DISTRIBUTION IN A VERY HIGH-FREQUENCY DISCHARGE IN HYDROGEN.
F.Ciorăscu.
Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 1, 41-53 (1957).
In Roumanian.
An attempt is made to interpret the experimental results obtained in an earlier paper concerned with the Maxwellian distribution of velocities of free electrons in a high-frequency discharge in hydrogen at low pressures with weak fields. The agreement observed between the values of the free electron density $N^-$ found from Langmuir probe characteristics, and using the dispersion formula to find the active and reactive parts of the impedance of the gas, is taken to show that the two results are consistent with the hypothesis that for a given gas pressure the electron collision frequency is a constant. It is pointed out that the electron collision frequency differs only by the constant factor g appearing in the dispersion formula. The factor g is calculated from the gas conductance data, as shown in the earlier paper, and its values are plotted. It is noted that they are not constant as would be the case for lower electron temperatures.
W.G.Townsend

4588 A 30-KILOWATT, 500-MICROSECOND VACUUM TUBE PULSER. R.A.Kawcyn.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 56-7 (Jan., 1961).
A vacuum-tube pulser is described which was developed for the operation of gas discharge tubes used in plasma research. It is capable of supplying a load with rectangular current pulses of as

much as 12 to 15 A for durations from 30 to 500 μsec with a voltage drop across the load up to 3500 V. The maximum duty cycle at high currents is 0.005.

4589 SKIN EFFECT AND SHOCK WAVES IN AN INDUCED GAS DISCHARGE. S.E.Grebenshchikov and M.D.Raizer.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1665-7 (June, 1960). In Russian.

A gas discharge in air or hydrogen induced at a frequency of 300 kc/s was investigated. The shock wave front was found to break away from the current layer. The current distribution in the discharge chamber was determined by the nature of the skin effect in metallic conductors. [English translation in: Soviet Physics – JETP (USA), Vol. 11, No. 6, 1201-2 (Dec., 1960)].

# PLASMA

*(See also Magnetohydrodynamics)*

4590 THERMODYNAMIC FUNCTIONS OF A LOW-TEMPERATURE PLASMA. A.I.Larkin.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1896-8 (June, 1960). In Russian.

Thermodynamic functions of a plasma are calculated for temperatures below the ionization temperature. It is shown that a correct allowance for the interaction between ions and electrons with a continuous spectrum partly compensates the contribution from the excited states of atoms and complex ions. [English translation in: Soviet Physics–JETP (USA), Vol. 11, No. 6, 1363-4 (Dec., 1960)].

4591 STATISTICAL DISTRIBUTION OF THE MAGNETIC MICROFIELD IN A PLASMA. G.Kalman.
Phys. of Fluids (USA), Vol. 4, No. 3, 300-1 (March, 1961).

The static magnetic field due to randomly distributed charged particles in phase space is investigated. A Holtsmark-like distribution is derived, centred around $2.0091\,B_0$, the latter being the magnetic field caused by a particle moving with the average velocity at an average interparticle distance.

4592 LAGRANGEAN DENSITY FOR AN INVISCID, PERFECT, COMPRESSIBLE PLASMA. S.Katz.
Phys. of Fluids (USA), Vol. 4, No. 3, 345-8 (March, 1961).

A Lagrangean density formulated in the Lagrangean coordinate system is proposed for a one-fluid, inviscid, perfect, compressible plasma undergoing isentropic motion in an electromagnetic field. Variations of the electromagnetic field potentials yield Maxwell's equations, while variations in the particle paths result in the equations of fluid motion.

4593 A KINETIC EQUATION FOR RAPIDLY VARYING PROCESSES. V.P.Silin.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1771-7 (June, 1960). In Russian.

A kinetic equation is considered for processes characterized by times which are small or comparable with the collision times. In the most interesting case of a charged-particle gas in the absence of a magnetic field and for frequencies which greatly exceed the Langmuir frequency $\omega_0$, it is found that the distance traversed by a particle during the field oscillation period, and not the Debye screening radius, appears as the maximal impact parameter in the Coulomb logarithm. The effective frequency of collisions between electrons and ions which determines the dissipative part of the complex permittivity tensor, in a plasma located in a strong constant magnetic field is computed for the same case of high frequencies. If, moreover, the electron Larmor frequency is much greater than the Langmuir frequency the maximal impact parameter in the Coulomb logarithm is found to depend in a resonance manner on the frequency of the alternating field. [English translation in: Soviet Physics–JETP (USA), Vol. 11, No. 6, 1277-80 (Dec., 1960)].

4594 ON A MOVING BOUNDARY PROBLEM. S.Katz.
J. math. Phys. (USA), Vol. 2, No. 1, 149-50 (Jan.-Feb., 1961).

An exact analytic solution is obtained for a uniformly expanding, neutral, infinitely conducting plasma sphere in an external uniform and constant magnetic field.

4595 THE CHARGE CORRELATION FUNCTION OF A PLASMA IN A MAGNETIC FIELD. S.F.Edwards.
Phil. Mag. (GB), Vol. 6, 61-9 (Jan., 1961).

A linear integral equation is derived for the correlation function in the presence of a magnetic field. The equation is solved and the errors estimated.

4596 LOW-DENSITY PLASMA FLOW AT A MAGNETIC BARRIER. M.A.Gilleo.
Phys. of Fluids (USA), Vol. 4, No. 2, 210-14 (Feb., 1961).

The encounter of a low-density of plasma with a barrier in otherwise uniform axial magnetic field is treated theoretically on the basis of particle dynamics. Conditions are considered for which the magnetic moments which result from the transverse velocities of the particles are adiabatically invariant within the barrier region. At the barrier there is an increase of magnetic field caused by external currents and increase in electric potential $\phi$ caused by charge separation in the plasma. Within the barrier the electric potential brings about an exchange of energy $e\phi$ between ions which carry the kinetic energy of the stream and electrons so that both may penetrate in equal number. The penetration of the barrier, the force on it, and the change of electric potential in it are given in terms of the ratio of barrier to guiding-field, stream velocity, and the temperatures of the ions and electrons. A comparison is made with results which have been obtained for an encounter in which the barrier rises so rapidly that the moment of the ions is not adiabatically invariant and for which the Rosenbluth–Garwin sheath model has been employed. This model is appropriate to cases in which a rapidly varying current flows on the surface of the plasma (skin effect) as in the pinch effect. Much greater penetration takes place with the slowly varying magnetic field which may be encountered when the field is produced by current-carrying conductors external to the plasma.

4597 THE FLOW OF A PLASMA INTO VACUUM IN THE PRESENCE OF A MAGNETIC FIELD. R.V.Polovin.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 657-61 (Sept., 1960). In Russian.

Hydromagnetic waves excited by disintegration of the boundary between a plasma and vacuum are investigated. The boundary velocity (escape velocity) is determined. The amplitude of electromagnetic waves emitted in vacuum during disintegration of the boundary is determined. [English translation in: Soviet Physics–JETP (USA), Vol. 12, No. 3, 461-3 (March, 1961)].

4598 BEHAVIOUR OF A PLASMA IN AN ALTERNATING MAGNETIC FIELD.
I.M.Zolototrubov, N.M.Pyzhov, I.P.Skoblik and V.T.Tolok.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 769-73 (July, 1960). In Russian.

For abstract, see Abstr. 17008 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 722-6 (Jan., 1961)].

4599 A NEW APPROACH TO TRANSPORT PROBLEMS IN FULLY IONIZED PLASMAS.
S.F.Edwards and J.J.Sanderson.
Phil. Mag. (GB), Vol. 6, 71-87 (Jan., 1961).

Exact formulae for transport coefficients are given in terms of one and two-body equilibrium Green functions in velocity space. Equations are derived for these Green functions which apply under plasma conditions and which automatically include shielding and plasma oscillation effects. The method is illustrated by simple examples.

4600 DIFFUSION OF A COLD CESIUM PLASMA ACROSS A MAGNETIC FIELD. N.D'Angelo and N.Rynn.
Phys. of Fluids (USA), Vol. 4, No. 2, 275-6 (Feb., 1961).

A column of Cs plasma (~ 1 cm radius, electron density $\sim 5 \times 10^{10}$ cm$^{-3}$, 30-40% ionized) was generated in a magnetic field of strength B up to 10kG, by ionization of atomic beams falling on hot tungsten plates. The electron density was measured as a function of radius with a Langmuir probe, and fitted to cylindrical solutions of the diffusion equation. The diffusion coefficients thus found appear to be proportional to $B^{-2}$, and to be of the magnitude required by classical plasma theory. R.S.Pease

4601 INSTABILITY OF A PLASMA WITH AN ANISOTROPIC DISTRIBUTION OF ION AND ELECTRON VELOCITIES.
.B.Kitsenko and K.N.Stepanov.
h. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1840-6 (June, 1960).
Russian.

A study is made of the propagation of magnetohydrodynamic aves in an infinite-rarefied plasma with an anisotropic distribution charged-particle velocities. Conditions under which instability ppears as a result of the anisotropy of the distribution functions are erived. It is shown that the kinetic treatment leads to an increase the instability region compared with that obtained in the quasi-ydrodynamic approximation. [English translation in: Soviet hysics–JETP (USA), Vol. 11, No. 6, 1323-7 (Dec., 1960)].

4602 INVESTIGATION OF THE STABILITY OF A PLASMA BY A GENERALIZED ENERGY PRINCIPLE.
.F.Aleksin and V.I.Yashin.
h. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 822-6 (Sept., 1960).
Russian.

Stability conditions are derived for a plasma possessing an nisotropic particle velocity distribution and located in a cylindrically symmetric magnetic field. Cases of longitudinal and azimuthal agnetic fields are considered. [English translation in: Soviet hysics–JETP (USA), Vol. 12, No. 3, 572-4 (March, 1961)].

4603 EXPERIMENTAL INVESTIGATION OF THE DIFFUSION BREAK-UP OF A PLASMA IN A MAGNETIC FIELD.
.E.Golant and A.P.Zhilinskii.
h. tekh. Fiz. (USSR), Vol. 30, No. 7, 745-55 (July, 1960).
n Russian.

For abstract, see Abstr. 17015 of 1960. [English translation in: oviet Physics–Technical Physics (USA), Vol. 5, No. 7, 699-708 Jan., 1961)].

4604 DIFFUSION OF CHARGED PARTICLES ACROSS A MAGNETIC FIELD IN A THREE-COMPONENT PLASMA.
.E.Golant.
h. tekh. Fiz. (USSR), Vol. 30, No. 8, 881-92 (Aug., 1960). In ussian.

For abstract, see Abstr. 17016 of 1960. [English translation in: oviet Physics–Technical Physics (USA), Vol. 5, No. 8, 831-41 Feb., 1961)].

4605 COLLISIONS OF PARTICLES IN A HIGH-TEMPERATURE PLASMA. O.V.Konstantinov and V.I.Perel'.
h. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 861-71 (Sept., 1960).
n Russian.

A kinetic equation is derived for a high-temperature plasma. he effective cross-sections for collisions between electron and or electron–ion collisions are computed without artificially cutng off the interaction. The role of plasma oscillations in the lasma kinetics is discussed. It is shown that the effect of ions n screening of the interaction during electron–ion collisions should e taken into account. [English translation in: Soviet Physics–ETP(USA), Vol. 12, No. 3, 597-603 (March, 1961)].

PAIR DISTRIBUTION FUNCTION OF A LOW-DENSITY HIGH-EMPERATURE PLASMA. See Abstr. 4273

4606 CHERENKOV GENERATION OF HYDROMAGNETIC AND MAGNETOACOUSTIC WAVES IN A RAREFIED NISOTROPIC PLASMA. N.L.Tsintsadze and A.D.Pataraja.
h. tekh. Fiz. (USSR), Vol. 30, No. 10, 1178-85 (Oct., 1960).
n Russian.

If the mean free path in a plasma is comparable with the linear xtent of the plasma, the stresses in it may be anisotropic. In the resence of an external magnetic field different kinds of waves are ropagated in the plasma. Expressions for their dispersion laws re given for the hydromagnetic and for the magnetoacoustic waves. Waves may be generated by charged moving filaments or linear arriers of current, if their speed is sufficient. Expressions are btained for the intensity of these "Cherenkov waves". [English ranslation in: Soviet Physics – Technical Physics (USA), Vol. 5, o. 10, 1113-21 (April, 1961)]. R.Eisenschitz

CHERENKOV RADIATION IN A MAGNETOACTIVE PLASMA. See Abstr. 3159

4607 ON THE ANGULAR DISTRIBUTION OF CYCLOTRON RADIATION FROM A HOT PLASMA. B.A.Trubnikov.
Phys. of Fluids (USA), Vol. 4, No. 2, 195-8 (Feb., 1961).

It is shown that the formula of Drummond and Rosenbluth (Abstr. 3773 of 1960) for the angular dependence of the absorption coefficient of cyclotron radiation from a hot plasma is too crude, and hence the numerical estimates based on this formula for the total radiation from a plasma layer turn out to be less valid than the previous results obtained by the present author.

4608 CYCLOTRON RADIATION FROM A HOT PLASMA. J.L.Hirshfield, D.E.Baldwin and S.C.Brown.
Phys. of Fluids (USA), Vol. 4, No. 2, 198-203 (Feb., 1961).

Calculations of the incoherent cyclotron radiation from a hot plasma, based upon the single-particle model of Trubnikov and Bazhanova (1958-9) are presented. It is shown that the emission at frequencies higher than the blackbody cut-off frequency is not negligible under certain conditions, especially since it is relatively unaffected by proposed reflectors. An approximate absorption coefficient, which is inferred from the calculations, is used to obtain the real part of the refractive index from the Kramers–Kronig transform for comparison with the results of Drummond and Rosenbluth (Abstr. 3773 of 1960).

4609 COMMENT ON THE ANGULAR DEPENDENCE OF PLASMA SYNCHROTRON EMISSION.
D.B.Beard and J.C.Baker.
Phys. of Fluids (USA), Vol. 4, No. 2, 278 (Feb., 1961).

Numerical methods show that the Drummond and Rosenbluth approximation (Abstr. 3773 of 1960) is a very good one for an electron gas with velocity vectors perpendicular to the magnetic field. R.S.Pease

ELECTROMAGNETIC WAVES IN A HALF-SPACE FILLED WITH A PLASMA. See Abstr. 1729

4610 HYDROMAGNETIC EQUILIBRIA IN A TOROID FROM THE PARTICLE POINT OF VIEW. R.M.Kulsrud.
Phys. of Fluids (USA), Vol. 4, No. 3, 302-14 (March, 1961).

Hydromagnetic equilibria are considered as being time-independent solutions of Boltzmann's equations and Maxwell's equations. The short-range collisions are neglected and the magnetic field is taken large enough to make the small gyration radius low-frequency expansion of the equations by Chew, Goldberger and Low (unpublished work) applicable. The equilibria are discussed only to lowest order in this scheme and in geometries topologically equivalent to a torus. In particular, magnetic surfaces are shown to exist. A set of invariants for slow motions of the system are determined. These invariants are used as constraints in a variational principle which states that subject to these constraints an arbitrary configuration makes the energy stationary if, and only if, it is an equilibrium state. The case of equilibria with trapped particles is treated separately. It is proposed that the values of these invariants serve to characterize toroidal hydromagnetic equilibria.

4611 HYDROMAGNETIC STABILITY OF A TUBULAR PINCH. W.A.Newcomb and A.N.Kaufman.
Phys. of Fluids (USA), Vol. 4, No. 3, 314-34 (March, 1961).

Necessary and sufficient conditions are derived for the hydromagnetic stability of a tubular pinch with a very thin current layer. The derivation is based on the energy principle, according to which a system is stable if, and only if, the energy integral is positive for every virtual displacement. The virtual displacements are divided into two types, depending on whether their radial components are continuous or discontinuous in the limit of an infinitely thin layer. Separate stability criteria are given for each type, and stability diagrams are constructed on the basis of numerical calculations. The tubular-pinch results are supplemented with a brief discussion of the columnar pinch, and it is concluded that the tubular pinch is easier to stabilize.

PINCH EFFECT IN A LOW PRESSURE ARC. See Abstr. 4583

4612 HIGH-FREQUENCY POTENTIAL WELL FOR DENSE PLASMAS. A.J.Hatch.
Phys. Rev. Letters (USA), Vol. 6, No. 2, 53-5 (Jan. 15, 1961).

The potential of a perfectly conducting sphere of plasma in a

cavity excited in the magnetic quadrupole mode has a configuration analagous to that of the static magnetic cusp field. Such a configuration offers a new approach to the containment of dense plasmas.
J.W.Sturgess

4613 THE STABILITY OF A PLASMA CYLINDER IN A HIGH-FREQUENCY MAGNETIC FIELD. T.F.Volkov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 5, 497-503 (May, 1960). In Russian.

It is shown that a quasi-stationary high-frequency magnetic field having a sufficiently large amplitude and directed along the main axis can improve the stability of a plasma cylinder with respect to small perturbations of any kind. A high-frequency magnetic field rotating around the axis does not add to the stability. The problem is treated in the hydromagnetic approximation. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 5, 467-72 (Nov., 1960)]. G.Martelli

4614 THE STABILITY OF A THIN RING-SHAPED PLASMA CONDUCTOR IN A MAGNETIC FIELD. II.
Yu.V.Vandakurov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 781-9 (July, 1960). In Russian.

For abstract, see Abstr. 19674 of 1960. [English translation in Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 734-43 (Jan., 1961)].

4615 PIEZOELECTRIC PROBE FOR PLASMA RESEARCH.
M.O.Stern and E.N.Dacus.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 140-3 (Feb., 1961).

The probe may be used to measure phenomena of short time duration (microseconds) giving rise to moderately small pressures (fractions of an atmosphere). Some response characteristics and a method for calibration are also presented.

4616 MICROWAVE INVESTIGATIONS OF PLASMA IN THE APPARATUS "ALPHA".
V.A.Anoshkin, V.E.Golant, B.P.Konstantinov, B.P.Poloskin and O.N.Shcherbinin.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1447-55 (Dec., 1960). In Russian.

The behaviour of plasma near the walls of the containing vessel during and after discharge is studied by reflecting microwaves from it. Movement of plasma layers of specified density can thus be tracked. The movement is found to be complex. Oscillations occur, but there is a general movement towards the inner wall of the toroidal vessel. Plasma concentration builds up sooner and lasts longer near the outer wall. [English translation in: Soviet Physics–Technical Physics (USA)]. A.E.I.Research Laboratory

4617 INVESTIGATION OF THE ELECTRIC AND MAGNETIC CHARACTERISTICS OF THE DISCHARGE IN THE APPARATUS "ALPHA". V.A.Glukhikh, D.E.Zavarin, E.G.Komar, B.A.Larionov, N.A.Monoszon, V.V.Skotnikov and A.M.Stolov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1404-14 (Dec., 1960). In Russian.

The current in the discharge and the plasma resistance depend on the capacitor voltage and the initial value of the magnetic field. Curves are plotted to show this. The plasma resistance also depends on the time of discharge. The current density and magnetic field vary across the path of the discharge, and measurements of these were made. Information thus gained helps in estimating the electron temperature and improves understanding of the self-compression process. [English translation in: Soviet Physics–Technical Physics (USA)]. A.E.I Research Laboratory

4618 PRODUCTION AND ANALYSIS OF A LARGE-DIAMETER PLASMA BEAM.
B.B.Meckel and P.A.Harkins.
J. appl. Phys. (USA), Vol. 32, No. 3, 489-93 (March, 1961).

A continuously operating low-velocity plasma accelerator is described which has a beam diameter of 3.6 cm. The beam is produced by extracting ions from a discreetly generated singly charged ion plasma in the following manner: A fine wire mesh placed so that one side is exposed to the plasma acts as a solid flat cathode when given a negative potential. Some of the ions which are attracted to the mesh pass between the wires and stream into the region behind the mesh where they enter a field of thermionically emitted electrons. The resulting beam consists of a stream of parallel-flowing ions with a compensated negative space-charge atmosphere of randomly moving electrons. Beam densities of $2 \times 10^8$ ions/cm$^3$ of 100 eV Hg+ ions are obtainable 15 cm from the extractor. Gas pressures are maintained which provide mean free paths which are long compared to the tube dimensions. The diagnostic techniques used to analyse the beam parameters are described. The system is versatile and may be altered to permit the use of other gases, pressures and ion velocities.

4619 THE ULTRA-HIGH-VACUUM SYSTEM FOR THE C-STELLARATOR. K.Dreyer and J.T.Mark.
RCA Rev. (USA), Vol. 21, No. 4, 508-46 (Dec., 1960).

In building the vacuum system it was first necessary to solve many problems of design and fabrication of the component parts. Final assembly did not impose serious hardships, except in cases where the preliminary work proved to be inadequate. The paper describes much new knowledge gained during the course of the work. The welding and joining of stainless steels, the assembling of glass and ceramics into vacuum vessel systems, and the achievement of an ultra-high vacuum and its accurate measurement are described. Many of the arts of electrical control systems, material cleaning, lubrication and movement of parts in vacuum, and electrical and thermal insulation, are also discussed.

4620 MAGNETIC TRAP WITH ROTATING STOPPERS (MIRRORS). L.I.Rudakov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 907-12 (Aug., 1960). In Russian.

For abstract, see Abstr. 17002 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 8, 853-7 (Feb., 1961)].

## Plasma Oscillations

4621 FREE OSCILLATIONS OF A BOUNDED PLASMA. D.A.Frank-Kamenetskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 669-79 (Sept., 1960). In Russian.

The general properties of cylindrical waves in a cold plasma are considered. The results obtained are applied to low-frequency free oscillations of a plasma cylinder surrounded by conducting walls. The conditions for magneto-acoustic resonances are derived, which ensure an effective penetration of the oscillations into the plasma The nature of the resonance phenomena depends on the linear density of electrons. Approximate formulae are given for the natural frequencies of a long plasma cylinder. It is shown that, in the vicinity of the mean geometrical value of the electron and ion cyclotron frequencies, purely radial oscillations are not possible since even small angular deviations alter sharply the resonance frequency. [English translation in: Soviet Physics–JETP (USA), Vol. 12, No. 3, 469-75 (March, 1961)].

4622 STATIONARY NONLINEAR PLASMA OSCILLATIONS. H.Wilhelmsson.
Phys. of Fluids (USA), Vol. 4, No. 3, 335-40 (March, 1961).

The frequency of nonlinear free oscillations is investigated in the following one-dimensional situations: (1) cold plasma including ion motion; (2) plasma with a spread in the velocity distribution; and (3) the two-stream case. In each case a dependence of the frequency on the degree of nonlinearity is obtained.

4623 GENERATION OF THE THIRD HARMONIC BY AN ELECTROMAGNETIC SIGNAL IN A PLASMA. P.Rosen.
Phys. of Fluids (USA), Vol. 4, No. 3, 341-5 (March, 1961).

By using the method of Margenau and Hartman (Abstr. 1249 of 1948) the amplitude of the third-harmonic current density is calculated. The equations lead to a tenable solution provided the field strength is small. An inequality is given for the region where the solution is valid.

4624 LINEARIZED PLASMA OSCILLATIONS IN ARBITRARY ELECTRON DISTRIBUTIONS.
G.E.Backus.
J. Math. Phys. (USA), Vol. 1, No. 6, 559 (Nov.-Dec., 1960).

Erratum. Gives a corrected proof of a theorum in an earlier paper with the above title (Abstr. 12622 of 1960).

4625 THE NON-LINEAR THEORY OF ELECTRON–ION PLASMA OSCILLATIONS. F.M.Nekrasov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 774-80 (July, 1960). In Russian.
For abstract, see Abstr. 19699 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 727-33 (Jan., 1961)].

4626 INSTABILITY OF LONGITUDINAL OSCILLATIONS OF A PLASMA OF ELECTRONS AND IONS PLACED IN AN EXTERNAL ELECTRIC FIELD. L.M.Kovrizhnykh.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1186-92 (Oct., 1960). In Russian.
The effect of the application of an electric field, variable in time but constant in space, to a homogeneous plasma is investigated by means of dispersion relations. It is found that the application to the plasma of an external electric field generates a drift of the electrons with respect to the ions. On the other hand, the presence of fluctuations in the charge density leads to the formation of plasma oscillations. For a sufficiently small relative velocity of the drift, the character of the oscillations is not affected, but as soon as it exceeds some critical value (which depends on the parameters of the plasma) the amplitude of the oscillations, with a wavelength longer than the Debye radius for the atoms, starts increasing. The energy of the orientated motion of the particles is transferred to the oscillations. The time required for the amplitude of a given harmonic to increase depends on the rate of change of the drift velocity. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 10, 1122-8 (April, 1961)]. G.Martelli

4627 MAGNETIC SOUND IN A THREE-COMPONENT PLASMA. D.A.Frank-Kamenetskii.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 893-8 (Aug., 1960). In Russian.
For abstract, see Abstr. 19694 of 1960. [ English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 8, 842-6 (Feb., 1961)].

4628 MAGNETO-ACOUSTIC RESONANCE IN A PLASMA. A.P.Akhmatov, P.I.Blinov, V.F.Bolotin, A.V.Borodin, P.P.Gavrin, E.K.Zavoiskii, I.A.Kovan, M.N.Oganov, B.I.Patrushev, E.V.Piskarev, V.D.Rusanov, G.E.Smolkin, A.R.Striganov, D.A.Frank-Kamenetskii, P.A.Cheremnykh and R.V.Chikin.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 536-44 (Sept., 1960). In Russian.
Reports an experimental study of magneto-acoustic oscillations in a cold plasma. It is shown that, under certain conditions a high-frequency electromagnetic field penetrates deeply into the plasma with a resonance absorption of the field energy. The results of investigation of resonance at frequencies of 12.5 and 50 Mc/s are described and compared with theoretical predictions. [English translation in: Soviet Physics–JETP (USA), Vol. 12, No. 3, 376-81 (March, 1961)].

4629 MAGNETO-ACOUSTIC RESONANCE IN A PLASMA. D.A.Frank-Kamenetskii.
Zh. tekh. fiz. (USSR), Vol. 30, No. 8, 899-906 (Aug., 1960). In Russian.
For abstract, see Abstr. 19695 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 8, 847-52 (Feb., 1961)].

# ELECTRON EMISSION
# ELECTRON BEAMS

4630 CONTRIBUTIONS TO THE NINTH ALL-UNION CONFERENCE ON CATHODE ELECTRONICS.
Izv. Akad. Nauk SSSR, Ser. fiz., Vol. 24, No. 6, 629-722 (1960). In Russian.
For abstracts of the papers presented at the above Conference see Abstr. 19711, 19722, 19728, 19801-2, 19805-9, 20142, 21172, 21245, 21297 of 1960; 327, 3019 of 1961.

4631 THE ALTERATION OF THE WORK FUNCTION OF METALS BY ADSORPTION OF GAS. A.Eberhagen.
Fortschr. Phys. (Germany), Vol. 8, No. 5-6, 245-94 (1960). In German.
An extensive survey. The main topics covered are: fundamentals and definitions; methods of measuring contact potential and work function; sources of error in these measurements; results of the measurements. J.Thewlis

4632 ON THE TEMPERATURE DEPENDENCE OF WORK FUNCTION OF SEMICONDUCTOR THERMOCATHODES. B.V.Bondarenko.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2140-51 (Sept., 1960). In Russian.
For abstract, see Abstr. 19707 of 1960. [English translation in: Soviet Physics–Solid State (USA), Vol. 2, No. 9, 1916-25 (March, 1961)].

FIELD EMISSION AND WORK FUNCTION STUDIES.
See Abstr. 4381

4633 INTERNAL FIELD EMISSION AND LOW TEMPERATURE THERMIONIC EMISSION INTO VACUUM. D.V.Geppert.
Proc. Inst. Radio Engrs (USA), Vol. 48, No. 9, 1644-6 (Sept., 1960).
For background see Mead [Abstr. 4285B of 1960; Proc. Inst. Radio Engrs (USA), Vol. 48, No. 3, 359-61 (March, 1960)]. Experimental results on Cu–$Cu_2O$ are reported. Point-contact current characteristics were observed on an oscilloscope. These agree with the theoretical expression

$$J = 2.17 \times 10^{-6} E^2 \exp\left(\frac{-57.9 \times 10^6}{E}\right)$$

when fitted at two points. Uses as a cold emitter are discussed. A.H.W.Beck

DIFFUSION OF MAGNESIUM IN CATHODE NICKEL.
See Abstr. 3686

4634 THE PHOTOELECTRIC EFFECT IN METALLIC CATHODES IN THE WAVELENGTH RANGE 1.39 TO 13.3 A. M.A.Rumsh, A.P.Lukirskii and V.N.Shchemelev.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 1, 55-7 (Nov. 1, 1960). In Russian.
Using a previously developed method (cf. Rumsh et al., Pribory i Tekh. Eksper., 1960, No. 5, 67-73) the variation of quantum yield with angle of incidence was measured. The results show that, except at small glancing angles, the quantum yield follows a cosecant law. The materials investigated include Cu, Ti, Ca, Mo, Si, Al and Mg, and the quantum yield increases in this order. A theoretical interpretation of the experimental results is given. [English translation in: Soviet Physics–Doklady (USA)]. A.E.I. Research Laboratory

THEORY OF PHOTOELECTRON EMISSION IN PARTIALLY POLARIZED LIGHT. See Abstr. 4182

4635 IMAGE CONVERTER FOR THERMAL RADIATION. M.Garbuny, T.P.Vogl and J.R.Hansen.
J. Opt. Soc. Amer., Vol. 51, No. 3, 261-73 (March, 1961).
The development of the photothermionic image converter is described, a device which reproduces scenes by virtue of differences in their thermal radiation. The method uses the principle of projecting a temperature image on a free multilayer film about 0.05$\mu$ thick which contains a photosurface with thermally sensitive yield. Image conversion is achieved by probing the temperature distribution with a flying light spot and displaying synchronously the thermally modulated photocurrent on a monitor. Under idealized shielding conditions, the relative temperature distributions in the image assume a very simple and general relationship to that of the object, e.g., are equal in radiation equilibrium. Practical heat exchange processes present other signal limitations which, in combination with the random noise inherent in any conversion process, determine the system performance. The paper considers the experimental work of searching for, and improving on, the phenomena in which the operation of the image converter is based. This includes theory and experiments on temperature sensitive photoelectric yields and on the electrical and optical properties of

thin films. Certain components such as sealed crystal windows, cooled radiation shields, and free thin films had to be developed for the image tube. Several models were built and accommodated by suitable optical and electronic systems. When completed, the device had television bandwidth and motion portrayal capabilities and the ability to detect, or image, temperature differences of 10° to 50°C.

4636 STATISTICS OF ELECTRON MULTIPLICATION. F.J.Lombard and F.Martin.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 200-1 (Feb., 1961).

The pulse-height distribution at the output of an electron multiplier structure for a single electron input is calculated assuming a Poisson distribution at each stage. Graphs are given which illustrate the change in pulse-height distribution as a function of the number of stages. This has been done for interstage multiplications of 1.5, 2.0, 3.0 and 5.0.

4637 ON CERTAIN REGULAR FEATURES OF THE SECONDARY ELECTRON EMISSION OF THIN LAYERS OF METALS AND SEMICONDUCTORS.
I.M.Bronshtein and B.S.Fraiman.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 5, 1097-1100 (Dec. 11, 1960). In Russian.

Refers to previous work (Abstr. 12360 of 1959) on the relation between low-energy secondary electron emission and high-energy elastic-plus-inelastic electron back-scattering. The present note is concerned with the experimental determination of the relation between these quantities for a wide range of materials in the form of a thin layer of one material deposited on a solid plate of another. The work was carried out in a vacuum of about $5 \times 10^{-8}$ mm Hg. Layers of lead on aluminium and silicon, titanium on beryllium and silver, and silicon on titanium were among these investigated. From their experimental results the authors derived a physical picture of the mechanisms influencing the relation between low-energy secondary emission and back-scattered high-energy electrons for incident electrons in the 1 keV range. [English translation in: Soviet Physics—Doklady (USA)]. A.E.I. Research Laboratory

4638 SECONDARY EMISSION OF GLASS NO. 48 BOMBARDED WITH POSITIVE IONS. G.M.Batanov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2048-57 (Sept., 1960). In Russian.

For abstract, see Abstr. 1909 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1839-46 (March, 1961)].

4639 THE SECONDARY ELECTRON EMISSION OF CALCIUM. I.M.Bronshtein and R.B.Segal'.
Radiotekhnika i Elektronika (USSR), Vol. 4, No. 3, 551-2 (March, 1959). In Russian.

The variation of the secondary electron emission coefficient $\sigma$ for a platinum target coated with layers of calcium of various thicknesses was investigated. The variation of $\sigma$ with primary electron energy for a thick layer of calcium was also measured. The results show that the maximum value of $\sigma$ is obtained for a calcium thickness of 0.6 atomic layers. It is also found that the thickness for which $\sigma$ is a maximum does not correspond to the thickness for which the thermal emission current is a maximum. R.C.Glass

SECONDARY EMISSION YIELD OF Cu—Be AND Ag—Mg UNDER Li-ION BOMBARDMENT. See Abstr. 4565

4640 FINE STRUCTURE OF SECONDARY EMISSION vs ANGLE OF INCIDENCE OF THE PRIMARY BEAM ON TITANIUM SINGLE CRYSTALS. R.W.Soshea and A.J.Dekker.
Phys. Rev. (USA), Vol. 121, No. 5, 1362-9 (March 1, 1961).

The secondary emission ratio of single crystal of titanium was measured as a function of the angle of incidence of the primary electron beam. The curves show a general increase of the secondary emission ratio with increasing angle between the electron beam and the normal to the crystal face. Superimposed upon this general increase are a number of small relative maxima. The larger and broader of these maxima occur whenever the primary beam is incident along one of the major zone axes of the crystal. The magnitudes of these bands vary with the energy of the incident electrons, but their angular position is independent of energy. The smaller, extremely narrow bands do not correspond to major zone axes of the crystal. Both the magnitude and angular position of these latter peaks vary with the primary energy. The origin of these bands is explained in terms of diffraction of the incident electrons by the crystal lattice.

4641 INTERPRETATION OF EXPERIMENTAL CHARACTERISTICS OF CESIUM THERMIONIC CONVERTERS.
E.N.Carabateas, S.D.Pezaris and G.N.Hatsopoulos.
J. appl. Phys. (USA), Vol. 32, No. 3, 352-8 (March, 1961).

Experimental V—I curves were obtained from a 150 W caesium thermionic converter. Two different kinds of V—I curves can be clearly distinguished. One, corresponding to a collision-free type operation, is obtained when the caesium mean free path is of the order of three or more times the interelectrode spacing. The other, corresponding to a sheath-type operation, is obtained when the spacing is of the order of 30 caesium mean free paths. In the first case the log I versus V plot has the familiar shape observed by Hernqvist et al., consisting of two straight lines meeting at the breakoff point. From such an experimental curve the difference in emitter and collector work functions and the emitter temperature can be readily obtained. In the second case the V—I curve has the standard shape of a sheath curve which is smooth without breakoff point and which shows saturation in the current for both the high positive and high negative values of the voltage. In the present work a method is outlined by means of which the difference in emitter and collector work functions, as well as the emitter temperature, can be determined from an experimental V—I curve of the second kind. With this method experimental data from the above mentioned converter in the sheath-type operation has been successfully analysed, and good agreement has been obtained between experimental results and theoretical predictions.

4642 MAGNETIC SYSTEM WITH AN INHOMOGENEOUS FIELD FOR THE EXPERIMENTAL INVESTIGATION OF ELECTRON TUBES. A.Ya.Sochnev.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 933-7 (Aug., 1960). In Russian.

For abstract, see Abstr. 17035 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 877-80 (Feb., 1961)].

4643 ON THE THEORY OF VACUUM THERMIONIC DIODES. N.I.Ionov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1210-14 (Oct., 1960). In Russian.

Derives, in an easily applicable form, the dependence of the characteristics of fully space-charge compensated diodes on the work functions and temperatures of the plane electrodes. A qualitative discussion is given of the application of the results to a real case of the electrodes made up of regions with different work functions. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 10, 1147-51 (April, 1961)]. R.Berman

4644 A METHOD OF NUMERICAL INTEGRATION OF MARGINAL TRAJECTORIES IN ELECTRON OPTICS.
R.Lapeyre and M.Laudet.
C.R. Acad. Sci. (France), Vol. 251, No. 18, 1874-6 (Oct. 31, 1960). In French.

The conditions are established for convergence of an iterative method of integrating the ray equation of electron optics, for the case of marginal paths. This leads to a new Runge—Kutta type of expression, which permits of fifth and fourth-order accuracy respectively in determining the function and its derivative. The method is applied to the numerical integration of the differential equation previously discussed (Abstr. 1914 of 1961) and a short table of results is given, to ten figures. V.E.Cosslett

4645 NUMERICAL INTEGRATION OF THE EQUATION OF MOTION OF A PARTICLE IN AN ELECTROMAGNETIC FIELD. R.Lapeyre.
C.R. Acad. Sci. (France), Vol. 251, No. 20, 2144-6 (Nov. 14, 1960). In French.

Expressions are established for integrating, by the Runge—Kutta method, the general equations of motion of a charged particle in an electromagnetic field (see preceding abstract). As a numerical example, the procedure is applied to the path of an electron in orthogonally crossed electric and magnetic fields, a table of results being given to ten places. V.E.Cosslett

4646 THE SIMULATION OF THE TRAJECTORIES OF RELATIVISTIC ELECTRONS IN A MAGNETIC UNDULATOR.
A.N.Výstavkin, Yu.V.Anisimova and S.S.Shakhidzhanov.
Radiotekhnika i Elektronika (USSR), Vol. 4, No. 3, 550-1 (March, 1959). In Russian.

Describes a method of studying the trajectories of relativistic electron beams in complex magnetic fields by observations at reduced energies. The method is applied to the investigation of electron paths in a magnetic undulator and gives results in agreement with previous ideas. R.C.Glass

4647 IRON-CLAD MAGNETIC CYLINDRICAL LENSES WITH A PLANE OF ANTISYMMETRY.
L.Ya.Yavor and M.Silad'i.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 927-32 (Aug., 1960). In Russian.

For abstract, see Abstr. 17040 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 872-6 (Feb., 1961)].

4648 APPLICATION OF AN IMAGE CONVERTER TO AN ELECTRON MICROSCOPE.
Yu.M.Kushnir, V.G.Nyrykov, M.M.Butslov and G.A.Bordovskii.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 73-5 (May-June). In Russian.

The application of an image converter for observation of low brightness images in an electron microscope is described. The application of the converter allows one to observe and focus images in both the transmission and the reflecting types of electron microscope with screen current densities equal to $10^5$-$10^6$ electrons/cm$^2$. This allows one to study objects which are either destroyed or suffer alterations under electron intensities ordinarily used in electron microscopes. [English translation in: Instrum. exper. Tech. (USA), No. 3, 398-402 (May-June, 1958; publ. June, 1959)].

4649 THE PROBLEM OF LENS ACHROMATIZATION AND SCALE DISTORTION CORRECTION IN REFLEX ELECTRON MICROSCOPES. G.V.Der-Shvarts and Yu.M.Kushnin.
Radiotekhnika i Elektronika (USSR), Vol. 4, No. 6, 1002-7 (June, 1959). In Russian.

The necessity of reducing the irradiation and observation angles in reflex electron microscopes in order to reduce chromatic aberration with consequent production of scale distortion has restricted their application. The problem of eliminating the chromatic aberration was investigated experimentally. It was found that the aberration could be reduced by reducing the focal length of the electron lens and that scale distortion could be partially eliminated by introducing a cylindrical magnetic lens into the system. R.C.Glass

FRINGES AT CRYSTAL EDGES IN ELECTRON-MICROSCOPE IMAGES. See Abstr. 4089

4650 OBTAINING A UNIFORM CONSTANT MAGNETIC FIELD IN A $\beta$-SPECTROGRAPH.
I.Osis and P.Prokof'ev.
Latv. PSR Zinat. Akad. Vestis (USSR), No. 9(158), 85-92 (1960). In Russian.

Points out that the uniformity of the magnetic field in the air gap of a permanent magnet is greatly affected by the particular method of magnetization adopted. A procedure is outlined for improving the field uniformity by a programme of current reversals. The method was successfully applied to a large magnet for a $\beta$-spectrograph; the field non-uniformity in the air gap was reduced from 2% to 0.15% in this way. A further reduction down to 0.08% was obtained by the use of shims. A.E.I. Research Laboratory

4651 DOUBLE-FOCUSING BETA SPECTROMETER WITHOUT IRON. V.F.Baranov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 15-21 (May-June). In Russian.

A description is given of a spectrometer with double focusing of the beam through an angle $\pi\sqrt{2}$ in the magnetic field of a system of circular coils not containing iron. The magnetic field in the median plane corresponds to the field of Pavinski or to fields characterized by the coefficients $\beta = \frac{1}{8}, \frac{1}{4}, \frac{3}{8}$ in the approximate theory of double focusing. The radius of the stable orbit is 100 mm, the maximum angles of divergence of the beam in radial and axial directions being, respectively, $\pm 10^0$ and $\pm 6^0$. The relative half-width of a line is 0.59% with the solid angle used of 0.6%. The instrument analyses electrons with maximum energies up to 0.3 MeV. [English translation in: Instrum. exper. Tech. (USA), No. 3, 334-40 (May-June, 1958; publ. June, 1959)].

# ION EMISSION . ION BEAMS

ALTERATION OF THE WORK FUNCTION OF METALS BY ADSORPTION OF GAS. See Abstr. 4631

4652 MASS SPECTROMETER INVESTIGATION OF SECONDARY POSITIVE AND NEGATIVE IONIC EMISSION, EXCITED BY THE BOMBARDMENT OF A MOLYBDENUM SURFACE BY POSITIVE IONS.
Ya.M.Fogel', R.P.Slabospitskii and I.M.Karnaukhov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 824-34 (July, 1960). In Russian.

For abstract, see Abstr. 17044 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 7, 777-85 (Jan., 1961)].

4653 THE INVESTIGATION OF THE POTENTIAL DISTRIBUTION IN A LAYER OF POSITIVE ION SPACE CHARGE. V.A.Ivanchenko and L.A.Sena.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 964-70 (Aug., 1960). In Russian.

For abstract, see Abstr. 17046 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 903-8 (Feb., 1961)].

4654 A SOURCE OF NEGATIVE HYDROGEN IONS.
Iu.M.Khirnyi.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 51-2 (March-April). In Russian.

Negative hydrogen ions are obtained by overcharging protons in hydrogen or deuterons in deuterium in the capillary of a high-voltage ion source. Currents of 20 $\mu$A for $H^-$ and 15 $\mu$A for $D^-$ were obtained. The hydrogen influx for a current of 20 $\mu$A for $H^-$ was 28 cm$^3$/hr. The lifetime of the source is more than 200 hr. [English translation in: Instrum. exper. Tech. (USA), No. 2, 231-3 (March-April, 1958; publ. April, 1959)].

4655 METHOD OF CONTROLLING THE OPERATION OF AN ION SOURCE. G.M.Osetinskii.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 103-4 (March-April). In Russian.

Data are presented for controlling the operation of an h.f. ion source by varying the voltage of the transverse magnetic field. The method used provides rapid adjustment of the source. [English translation in: Instrum. exper. Tech. (USA), No. 2, 291-3 (March-April, 1958; publ. April, 1959)].

4656 INVESTIGATION OF THE FOCUSING PROPERTIES OF AN ION EXTRACTION SYSTEM IN A HIGH-FREQUENCY ION SOURCE. A.N.Serbinov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 39-45 (May-June). In Russian.

The effect of the relationship of the geometrical dimensions of an ion extraction system to the focusing of a beam in the channel of the extracting electrode was investigated experimentally. The optimum ratio for the dimensions was found. Tests on three like systems with optimum dimensions, but which differed in channel diameters, gave the following results: with power supplied to the discharge of about 130 W and gas flows of 4, 8.5 and 13 cm/hr, ion sources were obtained of 0.88, 0.95 and 1.35 mA, respectively. The content of atomic ions was about 80%. [English translation in: Instrum. exper. Tech. (USA), No. 3, 360-6 (May-June, 1958; publ. June, 1959)].

4657 AN ION SOURCE OPERATED BY HIGH-FREQUENCY PULSES. G.S.Malkiel' and B.I.Sukhanov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 100-1 (May-June). In Russian.

The source produces ion current pulses of 100-200 mA of 1 $\mu$sec

duration and with a repetion frequency of 1000 per sec. [English translation in: Instrum. exper. Tech. (USA), No. 3, 431-2 (May-June, 1958; publ. June, 1959)].

4658 MOTION OF CHARGED PARTICLES AND CHARGED DISKS THROUGH AN ELECTRON–ION BEAM.
N.L.Tsintsadze.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 913-19 (Aug., 1960).
In Russian.

For abstract, see Abstr. 17048 of 1960. [English translation in: Soviet Physics–Technical physics (USA), Vol. 5, No. 8, 858-64 (Feb., 1961)].

4659 A 20-30 KILOVOLT ION GUN.
L.N.Bykhovskaya.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 49-51 (March-April). In Russian.

The principles and construction are described. The ion source is a high-voltage discharge. Data are presented of the dependence of the total discharge current and the current of the ion beam of the gun on the applied voltage for discharge chamber pressures of $1.8 \times 10^{-1}$ to $2.5 \times 10^{-1}$ mm Hg. [English translation in: Instrum. exper. Tech. (USA), No. 2, 228-30 (March-April, 1958; publ. April, 1959)].

4660 SIMULATOR FOR HIGH DENSITY ION GUNS.
R.Fox.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 77-82 (Jan., 1961).

A simulator for an ion gun is used to predict the ion trajectories in the gun for a given electrode geometry. One simulator control is used for the space charge simulation of the entire ion beam. The beam is divided into cells of different areas in such a manner that each cell has the same space charge. Potential measurements are made at the boundaries of the cells where the accuracy of the space charge simulation is the greatest. A trajectory plotter is described which consists of a miniature tricycle, a voltage balancing unit (the same unit used in d.c. millivolt recorders), a d.c. regulated power supply, and a number of resistors. The trajectories are found by "steering" the tricycle across the simulator. The trajectory plotter and the method of space charge simulation were checked experimentally and were found to have good accuracy.

4661 CALCULATIONS OF PROPERTIES OF MAGNETIC DEFLECTION SYSTEMS. S.Penner.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 150-60 (Feb., 1961).

A convenient matrix method for calculating properties of magnetic deflection systems is presented. This method is applicable to particle beams of small spatial and angular extent, and small energy spread. Equations for quadrupole lenses and for deflecting magnets are given. Examples are given to show the procedure for calculating the parameters of magnet systems.

4662 [ELECTRONIC] CURRENT STABILIZER FOR A PRECISION MASS SPECTROMETER [MAGNET].
V.P.Afanas'ev.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 59-62 (Jan.-Feb.).
In Russian.

The current range is from 50 mA to 1 A; the load current changes by less than $10^{-4}$% when the line voltage changes from 210 to 250 V. The drift after $1\frac{1}{2}$ hr running is less than $10^{-3}$% per hr. [English translation in: Instrum. exper. Tech. (USA), No. 1, 64-6 (Jan.-Feb., 1958; publ. April, 1959)].

4663 APPLICATION OF ELECTRON MULTIPLIERS TO INCREASE THE SENSITIVITY OF A MASS SPECTROMETER. M.G.Andreeva.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 53-6 (March-April).
In Russian.

An experiment is described to raise the sensitivity of a mass spectrometer (type MS-3) using an electron multiplier as an ion counter and industrial electronic apparatus to record the pulses. A comparison of the counting efficiencies for various ions was made. [English translation in: Instrum. exper. Tech. (USA), No. 2, 234-7 (March-April, 1958; publ. April, 1959)].

4664 INDUSTRIAL MASS SPECTROMETERS. PRODUCTION AND NEW DEVELOPMENTS [IN USSR]. REVIEW.
V.A.Pavlenko, A.E.Rafal'son and A.M.Shereshevskii.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 3-15 (May-June). In Russian.

[English translation in: Instrum. exper. Tech. (USA), No. 3, 319-33 (May-June, 1958; publ. June, 1959)].

4665 A NEW DESIGN OF PULSE MAGNETIC MASS SPECTROMETER WITH HIGH RESOLVING POWER.
B.N.Shustrov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 860-4 (July, 1960). In Russian.

For abstract, see Abstr. 17050 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 810-14 (Jan., 1961)].

4666 APPLICATION OF A DOUBLE DEFLECTION MAGNET SYSTEM IN MASS-SPECTROMETERS WITH HIGH DISPERSION. V.M.Kel'man, L.G.Knyaz'kov and E.K.Vasil'eva.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1193-8 (Oct., 1960).
In Russian.

Proposes a form of mass-spectrometer in which ions are first analysed in an electrostatic cylindrical spectrometer. Those that pass through the exit slit then traverse in succession two electromagnets with cylindrical pole-pieces, alike in design, but with fields in opposite directions. Both magnets produce 90° deflection but in opposition. The large overall dispersion of such a system is calculated. It is thought that the chief application would be to mass spectrometers possessing high dispersion but where the size of the magnets must be kept to a minimum. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 10, 1129-35 (April, 1961)]. A.E.I. Research Laboratory

4667 A PROPOSED METHOD FOR MEASURING RANGES OF HEAVY IONS IN SOLIDS.
D.I.Porat and K.Ramavataram.
Proc. Phys. Soc. (GB), Vol. 76, Pt 3, 438-9 (Sept., 1960).

Proposed the determination of the range–energy relationships fo heavy ions in solids by a comparison with the range of protons in the same material. A thick target is bombarded with monoenergetic ions whose range–energy relation is to be established. The ions came to rest at the average range R. The target is then bombarded with protons of energy sufficient to produce a known resonance in the ions deposited. As an example the determination of the range of carbon ions in gold is discussed.
R.H.Thomas

4668 RATE OF ENERGY LOSS AND RANGES OF CARBON AND OXYGEN IONS IN SOLIDS.
D.I.Porat and K.Ramavataram.
Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 97-102 (Jan., 1961).

The rate of energy loss of carbon and oxygen ions passing through carbon, aluminium, nickel, silver, and gold absorbers was measured in the energy interval of 0.36 to 3.2 MeV. Ranges of the carbon and oxygen ions in these stopping materials were obtained by numerical integration of the rate of energy loss against energy curve. The relative accuracy of the results is about 2% and the absolute accuracy is better than 5%.

4669 SPUTTERING YIELDS OF METALS FOR $Ar^+$ AND $Ne^+$ IONS WITH ENERGIES FROM 50 TO 600 eV.
N.Laegreid and G.K.Wehner.
J. appl. Phys. (USA), Vol. 32, No. 3, 365-9 (March, 1961).

Sputtering yields for polycrystalline metal and semiconductor targets under normally incident $A^+$ and $Ne^+$ ion bombardment were measured in the energy range from 50 to 600 eV. The yields (atoms/ion) were determined by measuring the weight loss of spherical targets immersed like large negative Langmuir probes in a dense low-pressure plasma (2-5 $\mu$ in A and ~ 40 $\mu$ in Ne), created in a demountable thermionic cathode, low-voltage discharge tube. The yields were found to be independent of gas pressure and ion current density. Sputtering sets in substantially at approximately the same ion energy for the various metal-gas combinations (40 to 60 eV) but with increasing ion energy rises differently for different materials. Comparing various materials, it is found that the yields increase consistently as the d shells are filled, with Cu, Ag, and Au having the highest yields.

4670 COLLISION THEORIES OF CATHODE SPUTTERING OF METALS AT LOW ION ENERGIES. E.B.Henschke.
nys. Rev. (USA), Vol. 121, No. 5, 1286-95 (March 1, 1961).

The periodicity of the threshold energies, as seen in a plot rsus atomic number, is more pronounced for threshold energies termined from the part of the yield curve at the lowest ion energies, hich obeys a quadratic law, than for "cut-in" energies determined ith a linear law from the adjacent somewhat higher ion energy nge. The relationship of the "empirical sputtering relation" of ehner (Abstr. 7541 of 1959) with the threshold formula, formerly rived by the author, is clarified. It is shown that in the case in hich the rebounding particle is believed to be a displaced target om, the assumption of a very large "effective" mass of the struck om must also be made to explain the rebound at angles as observed ejection patterns of single-crystal planes. Arguments are esented that the author's model is consistent with the observed gher yields of metals with completely filled d shells, such as Cu, g, and Au. The energy losses connected with the impulses used in Debye waves, as assumed in the author's theory, are shown to in good agreement with Silsbee's calculations (Abstr. 8450 of 58) of the energy losses in similar collisions.

4671 NEW METHOD FOR MEASURING SPUTTERING IN THE REGION NEAR THRESHOLD. D.McKeown.
ev. sci. Instrum. (USA), Vol. 32, No. 2, 133-6 (Feb., 1961).

Measurement is made using a plated quartz crystal oscillator. he crystal is placed in a molecular beam and sputtering of its ating is measured by the frequency change of the oscillator. The lationship between the frequency change of the oscillator and the nange in plating mass of the crystal is given. The method is tremely sensitive. Sputtering of less than a millimicrogram plating can be measured. A wide range of material can be used plate the crystal. A crystal oscillator sputtering gauge was built using a frequency counter with a digital readout to record the scillator frequency. The operation of the gauge is illustrated by eliminary measurements on the sputtering rates of gold in an gon beam between 0 and 100 eV. Other uses of the gauge, such a neutral beam detector, are also discussed.

4672 ETCH EFFECTS FROM OBLIQUE-INCIDENCE ION BOMBARDMENT.
.D.Magnuson, B.B.Meckel and P.A.Harkins.
. appl. Phys. (USA), Vol. 32, No. 3, 369-74 (March, 1961).

It was found that metallic surfaces of Cu, Au, Al, W, Ta, Mo, nd Ni when bombarded with 500 V $Hg^+$ ions at angles of incidence ther than zero, exhibit a definite surface structure or pattern. his pattern consists of hillocks or spires oriented parallel to the irection of the incoming ion beam. In Cu and Ni, steps oriented erpendicularly to the ion beam were also found. This surface attern provides visual evidence that the sputtering process at low on energies is a momentum transfer process. Since redeposition f sputtered atoms on the hillocks and steps could be quite large, ngle-of-incidence yield measurements could be in error unless nade before formation of the hillocks.

# PARTICLE ACCELERATORS

4673 THEORY OF THE CAPTURE OF PARTICLES INTO THE SYNCHRONOUS REGIME OF ACCELERATION AKING INTO ACCOUNT THE NONCONSERVATION OF THE QUATIONS OF MOTION. Yu.S.Sayasov and V.K.Mel'nikov.
h. tekh. Fiz. (USSR), Vol. 30, No. 6, 656-64 (June, 1960). In ussian.

The general equation of phase motion is given in the form /dt [m(t)$\dot{\psi}$] + f(t)U'($\psi$) = 0, where U'($\psi$) is a function of the synhronous phase angle and the phase angle of the test particle. A etailed examination is made assuming that m(t) and f(t) are varying n a time large compared with the period of linear phase oscilations. It is found that, under certain conditions, the capture width s 30% greater than that calculated in the conserved case. The esults can also be applied to linear accelerators. [English transation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 6, 18-26 (Dec., 1960)]. J.W.Sturgess

4674 CALCULATION OF THE PHASE TRAJECTORIES OF CHARGED PARTICLES TAKING INTO ACCOUNT THE COULOMB INTERACTION IN THE BUNCHER OF THE LINEAR ELECTRON ACCELERATOR. S.P.Lomnev.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 4, 822-4 (Dec. 1, 1960). In Russian.

On account of their complexity, the equations for electron phase trajectories are usually solved by a statistical approximation. With the help of modern digital computers, however, more rigorous solutions can be obtained. An example fully worked out by the author shows that only in low-current accelerators can Coulomb interaction be neglected; in high-current devices it assumes considerable importance. English translation in: Soviet Physics—Doklady (USA)]. A.E.I. Research Laboratory

4675 MICROWAVE SEPARATOR FOR HIGH ENERGY PARTICLE BEAMS. P.R.Phillips.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 13-16 (Jan., 1961).

The microwave separator described follows the original ideas of Panofsky and Wenzel [Abstr. 3006 B of 1957; Rev. Sci. Instrum., Vol. 27, No. 11, 967 (Nov., 1956)]. A $TM_{012}$ rectangular cavity is used with a Q of 15 000 and a maximum power dissipation of 1.3 MW. With this, electrons of 150 MeV/c momentum could be deflected through $\frac{3}{4}$ in. at the final focus of the analyzing magnet. The available aperture is so small that the technique is not immediately useful, but may become so at higher energies, when other methods of beam separation become unfeasible.

4676 VACUUM TECHNIQUES AND COMPONENTS USED FOR A CONTINUOUSLY PUMPED LINEAR ELECTRON ACCELERATOR. R.C.Marker.
Vacuum (GB), Vol. 9, 128-33 (May, 1959; publ. Dec., 1960).

A vacuum system has been designed to continuously pump a linear electron accelerator having an internal volume of approximately 30 l. and produce vacuums down to $1 \times 10^{-8}$ or better. The construction avoids all organic materials and is capable of being baked out at 450° C; design details of flanges, envelope construction, insulators and valves are discussed. Performance of the diffusion pump traps, which require no refrigeration, and their construction are described. Operating characteristics of the over-all system are discussed in terms of accelerator performance.

4677 SPLITTING OF AN ELECTRON BEAM AT THE EXIT OF A LINEAR ACCELERATOR BY MEANS OF AN ELECTROMAGNETIC WAVE IN A GUIDE. A.I.Zykov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 971-4 (Aug., 1960). In Russian.

For abstract, see Abstr. 17053 of 1961. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 909-11 (Feb., 1961)].

4678 THE MOTION OF A STRONGLY RELATIVISTIC ELECTRON IN A LINEAR ACCELERATOR UNDER THE ACTION OF RANDOM PERTURBATION. K.N.Stepanov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 975-80 (Aug., 1960). In Russian.

For abstract, see Abstr. 19826 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 912-17 (Feb., 1961)].

4679 STABILIZATION OF THE R.F. VOLTAGE APPLIED TO CYCLOTRON DEES.
A.V.Antonov, Yu.V.Korshunov, E.A.Meleshko and V.S.Panasyuk.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 41-6 (Jan.-Feb.). In Russian.

The principles of operation and a circuit diagram are given for a stabilizer which can be used for both continuous and pulsed operation. The control element operates on a low-level stage of the cyclotron oscillator. The individual sections of the control system are described. [English translation in: Instrum. exper. Tech. (USA), No. 1, 43-7 (Jan.-Feb., 1958; publ. April, 1959)].

4680 OPERATION OF A SYNCHROTRON WITH TWO INTERNAL TARGETS.
Yu.M.Ado, T.I.Savel'eva and B.N.Yablokov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 37-9 (May-June). In Russian.

On the basis of the experimental data, it is shown that the use of two internal targets located at different azimuths offers the possibility of significantly raising the efficiency of synchrotron operation. [English translation in: Instrum. exper. Tech. (USA), No. 3, 357-9 (May-June, 1958; publ. June, 1959)].

4681 RESONANT BEAM EXTRACTION FROM AN A.G. SYNCHROTRON. C.L.Hammer and L.J.Laslett.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 144-9 (Feb., 1961).

The resonant extraction method previously proposed for the normally constant gradient synchrotron has been extended to alternate gradient accelerators. It is found that perturbation field gradients which contain circular functions of arguments $2\nu_X$, $2\nu_X + 1$, $2\nu_X + 2$ are particularly effective in causing the radial betatron oscillations to grow exponentially at a particular azimuthal position. The analytical procedure for predicting which perturbations give optimum results, and digital computer calculations verifying these predictions, are presented.

4682 ON INTERNAL INJECTION OF ELECTRONS IN THE BETATRON. V.N.Logunov and S.S.Semenov.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 49-50 (Jan.-Feb.). In Russian.

Demonstrates experimentally that there is no difference between injecting on the outer and inner sides of the equilibrium orbit. [English translation in: Instrum. exper. Tech. (USA), No. 1, 52-3 (Jan.-Feb., 1958; publ. April, 1959)]. J.W.Sturgess

4683 A NEW METHOD FOR INVESTIGATING THE PROCESS OF INJECTION OF ELECTRONS IN THE BETATRON. A.P.Komar, G.F.Mikheev, V.P.Fominenko and N.N.Chernov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 855-9 (July, 1960). In Russian.

For abstract, see Abstr. 17061 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 7, 806-9 (Jan., 1961)].

4684 MODEL OF A CYLINDRICAL BETATRON WITHOUT IRON. Yu.S.Korobochko and K.S.Shilkov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 981-3 (Aug., 1960). In Russian.

For abstract, see Abstr. 17062 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 8, 918-19 (Feb., 1961)].

# X-RAY TUBES AND TECHNIQUES

4685 SEALED SHARP-FOCUSING PULSE X-RAY TUBES. V.P.Ziuzin, M.A.Manakova and V.A.Tsukerman.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 84-7 (Jan.-Feb.). In Russian.

Sealed tubes which produce short X-ray flashes by means of breaking down the gap between two electrodes in high vacuum are described. A needle-shaped tungsten anode provides a working focal spot of 3 mm diameter. It was shown that the tungsten evaporated from the surface of the anode needle in each flash tends to preserve high vacuum in the sealed tube. With a calculated striking circuit voltage of 1500 kV, sealed tubes provide over one hundred intense and easily usable X-ray flashes. [English translation in: Instrum.exper. Tech. (USA), No. 1, 92-5 (Jan.-Feb., 1958; publ. April, 1959)].

4686 SOME RESULTS OBTAINED IN DEVELOPING A RECORDING GEIGER-COUNTER X-RAY INTENSITY MONITOR. A.E.Kiss and N.Patla.
J. sci. Instrum. (GB), Vol. 38, No. 3, 78-9 (March, 1961).

A single-beam monitor is described which samples the general background radiation scattered from an X-ray beam by a thin foil, and its behaviour compared to that of the main spectrometer counter receiving the K component from the same beam. Equal fractional changes of counting rate for monitor and main counter are observed when X-ray beam fluctuations are caused by changes in the X-ray tube current. No such simple relationship holds between monitor and main counter for changes in X-ray tube voltage. The response required of a counter for monitoring purposes is discussed briefly and the suitability of an end-window argon-filled Geiger counter established experimentally.

4687 PHOTON-COUNTING SPECTROMETER FOR ATTENUATION MEASUREMENTS IN THE SOFT X-RAY REGION. D.E.Bedo and D.H.Tomboulian.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 184-8 (Feb., 1961).

A grazing incidence spectrograph, originally designed for photographic registration, is modified for the purpose of making attenuation measurements at selected wavelengths in the 100-300 A region. The modification include: (1) the introduction of an open multistage Cu—Be electron multiplier for the purpose of comparing intensities by counting photons; (2) the use of the characteristic valence emission bands of the light metals as sources of incident radiation. The photomultiplier is mounted on an arm attached to a spindle whose axis is normal to the base plate and passes through the Rowland circle at the selected wavelength. Defining slits, placed between the grating and entrance window of photomultiplier, limit the spectral band used in irradiating the absorbers. The latter are placed in the diffracted beam at the position of "least confusion" and may be rotated independently about the common vertical axis of the spindle, thus varying the angle at which the incident beam strikes the surface of the sample. Various tests indicate that the source intensity and detector sensitivity are adequate for the attainment of satisfactory counting rates. In conjunction with the particular sources referred to, the photon-counting scheme makes it possible to improve materially the precision of existing attenuation measurements.

# MAGNETISM

*(The magnetic properties of solids are included under Solid-State Physics; similarly for Liquid State and Gaseous State)*

4688 A NUCLEAR MAGNETOMETER. A.Ginzburg and B.Zheigurs.
Latv. PSR Zinat. Akad. Vestis (USSR), No. 5(154), 71-6 (1960). In Russian.

Describes the operating principles and detailed circuitry of a magnetometer based on nuclear resonance, in which a 1% aqueous solution of $FeCl_3$ is the resonating material, the pick-up volume is 0.1-0.05 $cm^3$, the modulation frequency is 99 c/s, and the minimum measurable magnetic field is 40 Oe with a pick-up of 0.1 $cm^3$. D.E.Brown

4689 INSTRUMENT FOR MEASURING THE AZIMUTHAL SYMMETRY OF THE FIELDS OF STRONG ELECTROMAGNETS [WITH ROUND POLE-PIECES]. M.P.Zel'dovich and S.M.Rubchinskii.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 56-8 (Jan.-Feb.). In Russian.

This instrument allows determinations of less than 0.05% deviation from azimuthal symmetry in the range of fields greater than 10 000 Oe. The principal circuits are given. [English translation in Instrum. exper. Tech. (USA), No. 1, 61-3 (Jan.-Feb., 1958; publ. April, 1959)].

4690 DETERMINING HYSTERESIS LOOPS USING MAGNETIC OPEN CIRCUITS. Y.Angel and G.Marie.
C.R.Acad. Sci. (France), Vol. 251, No. 17, 1727-9 (Oct. 24, 1960). In French.

An apparatus is described which permits accurate measurement of the hysteresis properties of open circuit magnetic specimens. The apparatus and technique were tested by making measurements on tubular specimens of outside diameter 4 mm and length varying between 6 and 20 cm. S.A.Ahern

4691 ACHIEVEMENT OF EXTREMELY HOMOGENEOUS MAGNETIC FIELDS. L.S.Goodman.
Rev. sci. Instrum. (USA), Vol. 31, No. 12, 1351-2 (Dec., 1960).

A layer of high-permeability material parallel with a magnet pole face but separated from it by a layer of non-magnetic material improves the homogeneity of the resultant field. A brief theory of the effect is given and in one example cited one piece of hypernom separated from a magnet pole face by $\frac{1}{16}$ in. reduced the transverse component by a factor 3000 to 1. More than one layer may be used. D.J.Olive

4692 POTENTIAL AND FIELD OF A UNIFORMLY CHARGED DISK; APPLICATION TO THE LEAKAGE FIELD OF A [DISK] MAGNET. M.Cotte and R.Durier.
C.R. Acad. Sci. (France), Vol. 251, No. 22, 2479-81 (Nov. 28, 1960). In French.

An expression is obtained for the field near the edge of a disk magnet, using elliptic integrals. J.Hawgood

4693 DISTRIBUTION OF FIELDS FROM RANDOMLY PLACED DIPOLES: FREE-PRECESSION SIGNAL DECAY AS RESULT OF MAGNETIC GRAINS. R.J.S.Brown.
Phys. Rev. (USA), Vol. 121, No. 5, 1379-82 (March 1, 1961).

Free-precession signals were observed from fluids in samples containing randomly distributed ferromagnetic grains. The local free-precession phase shift was calculated by computing ~~volumes of~~

ace for various ranges of perturbing field strength near individual ains. The frequency of occurrence of a given phase shift caused individual grains is inversely proportional to the square of the ase shift, this distribution being a limiting case of the Cauchy form. e resultant distribution of phase shifts from effects of many ains is then still of the Cauchy form. This leads to an exponential nal decay, with the rate independent of diffusion. If M is the ebraic sum of the individual dipole moments of the individual gnetic grains per unit volume, and $\gamma$ the magnetogryic ratio, $T_2 = (8\pi^2/9\sqrt{3})M\gamma$ if all grains are magnetized parallel to the pre-ssion field; $1/T_2 = (4\pi/3)M\gamma$ if perpendicular. Within 10%, $T_2 = 4.6M\gamma$ for any random or systematic orientation of the grains. easurements on water containing magnetite powder stabilized by rboxymethylcellulose and on glycerine containing magnetite wder, as well as on sands containing magnetite powder and satu-ted with water or glycerine, verified the exponential decay, indepen-nce of decay rate on diffusion or viscosity, and the above numeri-l value of decay rate (with small geometrical correction applied to sults for the sand system).

4694 LABORATORY ELECTROMAGNET. S.P.Kapitsa.
ribory i Tekh. Eksper. (USSR), 1958, No. 2, 97-9 (March-April). Russian.

The design is described and magnetic characteristics are ven of a medium-size general-purpose magnet providing a field 30 kG in a 10 mm gap for a power consumption of 3.6 kW. nglish translation in: Instrum. exper. Tech. (USA), No. 2, 6-8 (March-April, 1958; publ. April, 1959)].

4695 FOUR-INCH SHAPED POLE CAPS FOR SUSCEPTIBILITY MEASUREMENTS BY THE CURIE ETHOD. R.D.Heyding, J.B.Taylor and M.L.Hair.
ev. sci. Instrum. (USA), Vol. 32, No. 2, 161-3 (Feb., 1961).

Henry's profile (Abstr. 1194 of 1961) for shaped pole caps has een adapted to a 4 in. magnet. The fields obtained at a pole cap paration of 2.6 cm was examined in some detail. A region of nstant $\partial B^2/\partial x$ is obtained which is 1 cm in length at low fields nd 1.4 cm at high fields. For excitation currents of $40 \times 10^3$ np turns the value of $B\partial B/\partial x$ is about $24 \times 10^6$ gauss$^2$/cm.

4696 STABLE-OSCILLATION CONDITIONS FOR THE MAGNETIC-FILM PARAMETRON. R.M.Sanders.
appl. Phys. (USA), Vol. 32, No. 3, 478-82 (March, 1961).

A parametron can be constructed utilizing a single-domain agnetic-film with uniaxial anisotropy as the core of a nonlinear nductor absorbing energy from an alternating pump field applied n the plane of the film and delivering energy to a signal winding oupled to the film. Conditions for stable oscillations in such a evice are derived in a small-signal approximation for two cases: ) pump field parallel to the easy axis of the film magnetization and ignal winding coupled to the hard axis; (2) pump field parallel to ne hard axis and signal winding coupled to the easy axis. A d.c. ias field parallel to the pump field is considered separately from ne film anisotropy field. The Gilbert equation, as specialized by illette and Oshima for the film geometry, is used to describe hanges in the angle $\theta$ of the film magnetization. Results are: l) relations among the bias field, film and circuit parameters, and ne amplitude and phase of the pump field for a given oscillation mplitude in $\theta$; (2) the output-signal voltage, current, and power; 3) power dissipation by the film; (4) the approximate amplitudes of armonics in the oscillating variables; and (5) modifications in ircuit parameters to approximate the film gyromagnetic and amping effects. These results are expressed in terms of two unctions, completely describing the influence of all circuit para-neters through the effects of signal-winding current components n phase and in quadrature with oscillations in $\theta$. When plotted as uadrature components of a phasor in a rotating coordinate system, hese functions provide graphical means for determining stability onditions, amplitudes and phases of the oscillating variables, and he range of useful operating frequencies.

# ELECTROMAGNETISM MAGNETOHYDRODYNAMICS

4697 THEORETICAL INVESTIGATION OF THE BEHAVIOUR OF CHARGED PARTICLES IN THE SADDLE-POINT OF ALTERNATING ELECTRICAL FIELDS. A.Müller.
Ann. Phys. (Germany), Vol. 3, No. 3-4, 206-20 (1960). In German.

This is a theoretical discussion of the conditions necessary for the experimental findings of Straubel (Abstr. 1186 of 1956) that very small electrically-charged particles can be supported in free space in a coil or between two parallel wires to which a low-frequency, high-voltage alternating field is applied. The general case is investigated, including the effect of friction and of the earth's field, and then the particular configurations of two parallel wires, a ring, and a condenser with a slit or a circular aperture. New methods are proposed for finding the charge and the mass of the particles. V.E.Cosslett

4698 TIME-AVERAGED EFFECTS ON CHARGED PARTICLES IN A-C FIELDS. T.W.Johnston.
RCA Rev. (USA), Vol. 21, No. 4, 570-610 (Dec., 1960).

When a nonuniform a.c. fields is applied to a charged particle it experiences a time-averaged acceleration in addition to the a.c. acceleration. The development and application of the basic theory to plasmas is outlined, including some cases with a d.c. magnetic field. A fairly complete bibliography, and a critique of theory and experiments are also given.

4699 ON A POSSIBLE MECHANISM FOR THE CAPTURE OF CHARGED PARTICLES IN A MAGNETIC FIELD.
V.M.Vakhnin and G.A.Skuridin.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 6, 1354-7 (Dec. 21, 1960). In Russian.

Without loss of kinetic energy, charged particles cannot be captured by a magnetic field. In the "conservative" approach there is no such loss. Losses do, however, occur due to classical radiation, and under certain circumstances particles may be captured. This has particular application to terrestrial electricity and may help to explain radio stars. [English translation in: Soviet Physics–Doklady (USA)]. A.E.I. Research Laboratory

4700 MAGNETO-FLUID DYNAMICS.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 695-1028 (Oct., 1960).

Proceedings of a symposium sponsored by the International Union of Theoretical and Applied Mechanics in cooperation with the National Academy of Sciences — National Research Council. It was held in Williamsberg, Virginia and Washington, D.C. in January, 1960. Abstracts of the papers presented will be found in this or succeeding issues of Physics Abstracts.

4701 HYDROMAGNETIC FLOW IN A CIRCULAR PIPE. K.P.Chopra.
Z. Phys. (Germany), Vol. 162, No. 1, 46-52 (1961).

The flow is investigated of an electrically conducting liquid in a circular pipe when a uniform magnetic field is applied in a direction transverse to the direction of flow. It is found that the velocity profile of the liquid transforms itself from a parabola into a plateau as a magnetic field of greater strength is applied. This suggests that the induction drag is important in the central layers while the ordinary viscosity is dominant near the wall of the channel. These findings support the results obtained by Hartmann and Lazarus (1937). It is also shown that the treatment, though elementary in nature, is quite rigorous and does not need correction for the electromagnetic shielding effect.

4702 SOME CASES OF NON-STATIONARY FLOW OF A CONDUCTING FLUID IN AN ANNULAR TUBE.
Ya.S.Uflyand.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 799-802 (July, 1960). In Russian.

For abstract, see Abstr. 15122 of 1960. [English translation in: Soviet Physics–Technical Physics (USA), Vol. 5, No. 7, 753-5 (Jan., 1961)].

4703 NONSTATIONARY FLOW OF INCOMPRESSIBLE VISCOUS AND CONDUCTING FLUID IN THE PRESENCE OF TRANSVERSE MAGNETIC FIELD. I.B.Chekmarev.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 920-4 (Aug., 1960).
In Russian.

For abstract, see Abstr. 17083 of 1960. [English translation in: Soviet Physics — Technical Physics (USA), Vol. 5, No. 8, 865-9 (Feb., 1961)].

4704 FLOW OF CONDUCTING FLUID ROUND A SPHERE IN A STRONG MAGNETIC FIELD.
G.É.Gershuni and E.M.Zhukovitskii.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 8, 925-6 (Aug., 1960). In Russian.

For abstract, see Abstr. 17084 of 1960. [English translation in: Soviet Physics — Technical Physics (USA), Vol. 5, No. 8, 870-1(Feb., 1961)].

4705 STEADY FLOW OF AN ELECTRICALLY CONDUCTING LIQUID IN A RECTANGULAR CHANNEL IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD. Ya.S.Uflyand.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1256-8 (Oct., 1960). In Russian.

The flow is assumed laminar, the fluid viscous and incompressible, the walls perfectly conducting, and the applied magnetic field perpendicular to one pair of walls. The hydromagnetic equations are solved exactly by means of a Fourier series. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 10, 1191-3 (April, 1961)]. O.Penrose

4706 HARTMANN'S PROBLEM FOR A CIRCULAR TUBE. Ya.S.Uflyana.
Zh. tekh. Fiz (USSR), Vol. 30, No. 10, 1058-60 (Oct., 1960).
In Russian.

A conducting liquid is flowing through a tube of circular cross-section in an external uniform magnetic field perpendicular to the axis of the tube. The equations of magnetohydrodynamics are solved yielding analytical expressions for the local magnetic field strength and velocity. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 10, 1194-6 (April, 1961)]. R.Eisenschitz

4707 STABILITY OF A NON-UNIFORMLY-HEATED ELECTRICALLY-CONDUCTING LIQUID IN A MAGNETIC FIELD. E.M.Zhukhovitskii.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 3, 385-94 (1958).
In Russian.

Investigates the initial convective motion in an infinite vertical liquid cylinder. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 3, 1-12 (1958)].

4708 EXPERIMENTAL STUDY OF THE SETTING UP AND OF THE DECAY OF THE STEADY MOTION OF A CYLINDRICAL VOLUME OF CONDUCTING LIQUID ROTATING IN A MAGNETIC FIELD. Y.Poirier and J.Robert.
C.R. Acad. Sci. (France), Vol. 251, No. 25, 2880-2 (Dec. 19, 1960).
In French.

Observations following the sudden starting and stopping of the rotation of a cylinder containing carbon disulphide or mercury show that the transitions of liquid motion from rest to uniform rotation, and from uniform rotation to rest, are much more rapid than indicated by laminar theory. The observations are repeated in the presence of a magnetic field in the case of mercury, and a further reduction in transition times is found. R.A.Newing

4709 DYNAMIC STABILITY OF A CONDUCTING, CYLINDRICAL SHELL IN A MAGNETIC FIELD.
J.G.Linhart.
J. appl. Phys. (USA), Vol. 32, No. 3, 500-5 (March, 1961).

The dynamic stability of a thin, perfectly conducting cylindrical shell in axial and azimuthal magnetic fields is investigated by means of the method of normal modes. It is found that in cases where a growth of a surface perturbation is indicated, the e-folding time corresponds to the time required for the shell to collapse radially. Where stability is predicted, an initial surface perturbation can be shown to execute an oscillatory and damped motion.

4710 EXPERIMENTS ON HEAT TRANSPORT BY CONVECTION IN PRESENCE OF A MAGNETIC FIELD.
Y.Nakagawa and I.R.Goroff.
Phys. of Fluids (USA), Vol. 4, No. 3, 349-54 (March, 1961).

The effect of an impressed magnetic field on heat transport by convection was examined with a layer of mercury confined between two constant temperature surfaces and subjected to a uniform vertical magnetic field. Experiments were performed with the strength of magnetic field varying between 1195 and 1820 G. In agreement with the theoretical predictions by Nakagawa (Abstr. 3672 of 1960) the results show that the convective heat transport is characterized by a linear function of the applied temperature difference in the neighbourhood of the marginal state of stability, and the coefficient of proportionality, the Nusselt number, depends on the strength of the impressed magnetic field.

4711 THE EFFECT OF A ROTATING MAGNETIC FIELD ON THE TURBULENT HEAT TRANSFER IN MERCURY.
A.Veze and Ya.Klyavin'sh.
Latv. PSR Zinat. Akad. Vestis (USSR), No. 5(154), 67-70 (1960). In Russian.

A cylindrical solid was heated electrically. Heat was removed by convection in liquid mercury which was kept in turbulent motion by means of a rotating magnetic field. By measuring the temperature and the rate of evolution of heat, values of the heat transfer coefficient were obtained as a function of the rate of flow. The results are shown in a graph in which Nusselt's number is plotted against Péclet's number. It was found that the Nusselt numbers appropriate to flow in tubes were 20-40% smaller than those found in the present experiments. These measurements supplement known results for laminar flow which have been derived theoretically. R.Eisenschitz

4713 THE WAVE SURFACE IN MAGNETOHYDRODYNAMICS. I. C.Agostinelli.
RC Accad. Naz. Lincei (Italy), Vol. 28, No. 6, 746-50 (June, 1960).
In Italian.

Derivation of the Hamilton–Jacobi equation for wave fronts in a perfectly conducting compressible fluid in a magnetic field. O.Penrose

4712 THE STRUCTURE OF LOW-INTENSITY SHOCK WAVES IN MAGNETOHYDRODYNAMICS.
E.P.Sirotina and S.I.Syrovatskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 746-53 (Sept., 1960).
In Russian.

A general expression is deduced for the width of shock waves of low intensity in magnetohydrodynamics. The attenuation coefficient for small amplitude waves is determined and its relation to the discontinuity width is established. [English translation in: Soviet Physics JETP (USA), Vol. 12, No. 3, 521-6 (March, 1961)].

4714 THE WAVE SURFACE IN MAGNETOHYDRODYNAMICS. II. C.Agostinelli.
RC Accad. Naz. Lincei (Italy), Vol. 29, No. 1-2, 3-7 (July-Aug., 1960).
In Italian.

The results obtained in Pt I (preceding abstract) are applied to the special case of a compressible fluid with uniform sound speed and Alfvén velocity. An algebraic equation of the twelfth order, describing the wave front emitted by an instantaneous point disturbance is derived. O.Penrose

THE FLOW OF A PLASMA INTO VACUUM IN THE PRESENCE OF A MAGNETIC FIELD. See Abstr. 4597

# ELECTROMAGNETIC WAVES AND OSCILLATIONS

*(See also Plasma Oscillations)*

4715 THE HEAVISIDE OPERATIONAL CALCULUS ON A NEW BASIS. G.Wunsch.
Hochfrequenztech. u. ElektAkust. (Germany), Vol. 69, No. 4, 133-9 (Aug., 1960). In German.

The relationship between the conventional Heaviside methods and the more modern Laplace transformation is explained. One of the difficulties in using the older method was in coping with initial conditions. It is shown how to take account of these in a more satisfactory way. S.C.Du

4716 TRANSITION RADIATION EMITTED BY A CHARGE INCIDENT AT AN OBLIQUE ANGLE. G.M.Garibyan.
eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1814-16 (June, 1960).
ussian.
Radiation emitted in the forward direction by a charge during
ersal of an interface between two media at an oblique angle is
sidered. It is shown that the intensity of the radiation is almost
pendent of the angle of incidence of the particle, providing the
le is not close to a right angle. [English translation in: Soviet
sics—JETP (USA), Vol. 11, No. 6, 1306-7 (Dec., 1960)].

4717 THE THREE LEVEL SOLID STATE MASER. E.O.Schulz-Du Bois.
gress in cryogenics, Vol. 2 (see Abstr. 4509 of 1961) p. 173-231.
This review deals mainly with recent, including unpublished,
erimental and theoretical work at Bell Telephone Laboratories.
r a general introduction, paramagnetic resonance in crystals
iscussed, with reference to the spin Hamiltonian, energy levels,
sition probabilities, relaxation time, saturation behaviour and
rvey of maser materials. Three-level excitation is considered,
relaxation time ratio operation, frequency ratio operation and
optimization of maser material operation are described. The
itment of the interaction with the microwave circuit includes the
ry of the travelling-wave maser, the non-reciprocity require-
t and consideration of a practical travelling-wave maser. A
tion is devoted to noise — the desirability of low noise ampli-
tion, the noise theory of the travelling-wave maser, and a
cription of maser noise measurements. The final section
nds the three-level maser concept to heat engines, and spin
rigeration. 65 refs. J.B.Birks

OPERATIONAL RUBY MASER FOR OBSERVATIONS AT 21 cm
H A 60-FT RADIO TELESCOPE. See Abstr. 4214

SENSITIVITY OF A LOW-NOISE RADIOMETER. See
str. 4215

UPPER LIMITS FOR THE REVERBERATION TIME OF
VERBERATION CHAMBERS FOR ACOUSTIC AND ELECTRO-
AGNETIC WAVES. See Abstr. 4420

100 dB MICROWAVE SEMICONDUCTOR SWITCH.
Abstr. 4547

4718 ARBITRARY INCIDENCE OF A PLANE ELECTRO-MAGNETIC WAVE ON A CONDUCTING DISK.
N.Kuritsyn.
. tekh. Fiz. (USSR), Vol. 30, No. 7, 790-8 (July, 1960).
Russian.
For abstract, see Abstr. 15145 of 1960. [English translation in:
viet Physics—Technical Physics (USA), Vol. 5, No. 7, 744-52
n., 1961)].

4719 CALCULATION OF THE PHASE VELOCITIES OF WAVES IN AN ARTIFICIAL METAL DIELECTRIC.
.N.Fel'd and L.S.Benenson.
diotekhnika i Elektronika (USSR), Vol. 4, No. 3, 417-27 (March,
59). In Russian.
A simple method is outlined for calculating the phase velocity
waves in periodic metal-dielectric structures, which reduces,
sentially, to the method based on induced e.m.f.s. A characteristic
uation for the phase velocity is obtained, the solution of which is
itionary with respect to variations of current distribution on the
ements of the structure. The method is illustrated by an example
an artificial dielectric in the form of a three-dimensional lattice
metal elements. R.C.Glass

4720 PHASE SINGULARITIES FOR MICROWAVE LENSES WITH ABERRATIONS. L.Lee and G.W.Farnell.
Opt. Soc. Amer., Vol. 51, No. 3, 273-7 (March, 1961).
The dark rings of the Airy pattern in the focal region of a
icrowave lens form phase singularities. In an error-free lens
ese dark rings lie on the surface of a sphere. It is shown that in
e presence of primary aberrations the line singularities remain
osed loops and the phase behaviour near them is similar to that
the ideal lens. Third-order astigmatism of relatively small
nounts produces a marked distortion of the shape of the line
ngularity.

4721 REFRACTION AND DIFFRACTION OF PULSES. W.E.Williams.
Canad. J. Phys., Vol. 39, No. 2, 272-5 (Feb., 1961).
It is shown that the solution for the reflection and refraction of a plane pulse at a plane interface may be obtained, by Fourier synthesis, from the corresponding solution for a time-harmonic plane wave even when the angle of incidence is such that total reflection occurs. The application of the Fourier superposition method to problems involving both refraction and diffraction is also discussed.

RADIO WAVE ABSORPTION OF SEVERAL GASES IN THE 100 TO 117 kMc/s FREQUENCY RANGE. See Abstr. 4380

4722 ON THE THEORY OF DIFFRACTION BY A COMPOSITE CYLINDER. R.D.Kodis.
J.Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 1, 19-33 (Jan.-Feb., 1961).
Formulae are developed for the diffracted field around a perfectly conducting cylinder with a dielectric sleeve of arbitrary thickness. These formulae represent the field due to a unit electric line source parallel to the cylinder (either inside or outside the dielectric sleeve) as a spectrum of radial eigenfunctions. It is shown that in each case the field in the region containing the source can be expressed as the sum of two terms, the first of which is a spectral representation of the field when the outer as well as the inner surface of the dielectric is a perfectly conducting boundary. The second term of the sum, which alone involves the properties of the dielectric, is an integral that converges rapidly at high frequencies. Using these general results, perturbation calculations are carried out for three limiting examples of plane wave scattering: (1) Thin dielectric; (2) low-refractive index; (3) very small surface curvature. In the latter approximation the correspondence with optical results is shown.

LONG-DISTANCE E.M. WAVE PROPAGATION WAVEGUIDE THEORY. See Abstr. 4405

4723 INVESTIGATIONS OF HELIX — ANISOTROPIC DIELECTRIC AND HELIX — RIBBED STRUCTURE SLOW-WAVE SYSTEMS. II.
V.P.Shestopalov, V.A.Slyusarskii and K.P.Yatsuk.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 835-9 (July, 1960).
In Russian.
For abstract, see Abstr. 15151 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 7, 786-90 (Jan., 1961)].

4724 SLOW WAVES IN A HELICAL GUIDE WITH PLASMA. B.M.Bulgakov, V.P.Shestopalov, L.A.Shishkin and I.P.Yakimenko.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 840-50 (July, 1960).
In Russian.
For abstract, see Abstr. 17110 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 7, 791-801 (Jan., 1961)].

4725 COUPLING OF RECTANGULAR WAVEGUIDES BY MEANS OF A HOLE IN THE WIDE WALL. A.N.Akhiezer.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 7, 851-4 (July, 1960). In Russian.
For abstract, see Abstr. 17109 of 1960. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 7, 802-5 (Jan., 1961)].

4726 FIELD SOLUTION FOR A THIN-FILM SUPERCONDUCTING STRIP TRANSMISSION LINE.
J.C.Swihart.
J. appl. Phys. (USA), Vol. 32, No. 3, 461-9 (March, 1961).
By using Londons' equations, the two-fluid model, and the classical skin effect for the normal component of the current, a sinusoidal wave solution is found for a superconducting transmission line. This solution gives a slow mode of propagation which is dependent on the ratios of the dielectric and superconducting film thickness to the penetration depth. At low temperatures and frequencies where the losses are low, the velocity is dispersionless even though there is a component of electric field in the direction of propagation. The solutions for velocity and attenuation vary continuously as one passes through the critical temperature into the normal state. The solutions are interpreted in terms of lumped circuit characteristics.

4727 EQUIVALENCE BETWEEN CONTINUOUS AND DISCRETE RADIATING ARRAYS. A.Ksienski.
Canad. J. Phys., Vol. 39, No. 2, 335-49 (Feb., 1961).

The radiation patterns produced by continuous excitation distributions and discrete arrays are compared and the conditions are derived under which one type of source may be substituted for the other with negligible errors. It is shown that the aperture lengths in both cases should be the same but the element spacing is dependent on the type of pattern desired. Examples are computed to demonstrate these relations for both directive patterns and shaped beams.

4728 EVALUATION OF ERRORS ARISING IN THE THEORY OF ANTENNAE DUE TO THE USE OF GEOMETRICAL OPTICS. K Bochenek.
Bull. Acad. Polon. Sci. Ser. Sci. tech. (Poland), Vol. 7, No. 10, 589-92 (1959).

The field in the aperture of a lens or reflector antenna can be calculated approximately by the methods of geometrical optics. The accuracy of the approximation is discussed for a two-dimensional case. The method used is to develop the exact solution as a correction to that obtained from geometrical optics. W.T.Blackband

4729 ELECTROMAGNETIC WAVES IN A HALF-SPACE FILLED WITH A PLASMA.
Yu.N.Dnestrovskii and D.P.Kostomarov.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 3(9), 845-53 (Sept., 1960). In Russian.

Considers propagation of electromagnetic waves across a magnetic field in a half-space filled with a magnetoactive plasma. It is assumed that the plasma is confined by a stationary magnetic field H and the structure of this field is investigated for the case when the ratio of the plasma pressure to the magnetic pressure is small. It is demonstrated that at large distances from the plasma boundary an electromagnetic wave with an electric vector parallel to the magnetic field H has the form of a plane wave with a propagation constant which is specified by the equation for an infinite plasma. The reflection and transmission coefficients are evaluated for a plane wave reaching the plasma for vacuum. [English translation in: Soviet Physics—JETP (USA), Vol. 12, No. 3, 587-91 (March, 1961)].

4730 MATRIX FORM OF THE EQUATIONS OF PROPAGATION IN AN ANISOTROPIC MEDIUM WITH A CONSTANT MAGNETIC FIELD. P.Szulkin.
Bull. Acad. Polon. Sci. Ser. Sci. tech. (Poland), Vol. 8, No. 10, 581-7 (1959).

The problem of propagation of waves in a medium of variable ionization in the presence of a magnetostatic field is important in connection with ionospheric propagation. The solution is based on Maxwell's equations and Lorentz's equation of the motion of an electron in a field, neglecting the Lorentz polarization term, and is expressed in matrix form. V.G.Welsby

4731 MAGNETO-IONIC PROPAGATION PHENOMENA IN LOW- AND VERY-LOW-RADIOFREQUENCY WAVES REFLECTED BY THE IONOSPHERE. J.R.Johler.
J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 1, 53-65 (Jan.-Feb., 1961).

Ionosphere reflection coefficients at l.f.-v.l.f. which illustrate the dependence of the amplitude and phase of the reflected wave upon the direction of propagation relative to the direction of the earth's magnetic field are presented. The calculations are based on a plane, sharply bounded, model ionosphere with plane wave excitation, but employ full use of the magneto-ionic formulae for complex directions of propagation in the ionosphere such that the influence of the earth's magnetic field in the different directions of propagation is demonstrated. A special table of values applicable to v.l.f. is presented.

4732 A PROPOSED TECHNIQUE FOR F-LAYER SCATTER PROPAGATION. W.C.Vergara and J.L.Levatich.
Proc. Inst. Radio Engrs (USA), Vol. 48, No. 10, 1790 (Oct., 1960).

A method is suggested by which radio communication over great distances may be made at frequencies above the classical F2 MUF, employing a scatter mechanism. In order to prevent the operating frequency from exceeding the MUF by too great a margin, it is proposed to change it in sympathy with the temporal changes of the MUF. G.M.Brown

4733 MEASUREMENT OF THE VARIATION OF THE PHASE PATH OF A SIGNAL REFLECTED FROM THE IONOSPHERE. L.A.Drachev.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 56-61 (March-April). In Russian.

An apparatus is described to measure the variation of the phase path of a signal reflected from the ionosphere caused by movements of large-scale inhomogeneities. Changes of the phase path by any number of wavelengths can be recorded with an accuracy of half a wavelength. Changing the indicator enables statistical phase fluctuations to be measured with an accuracy of $\pm 1^0$. [English translation in: Instrum. exper. Tech. (USA), No. 2, 238-44 (March-April, 1958; publ. April, 1959)].

# Radiofrequency Spectroscopy Techniques

4734 NINTH AMPERE COLLOQUIUM (PISA, 12-16 SEPTEMBER, 1960).
Arch. Sci. (Switzerland), Vol. 13, Special No., 711 pp. (1960).

At this conference, which was very much larger than preceding ones, a total of 124 papers were presented in the following groups: (1) dielectric relaxation, paramagnetic relaxation, radiofrequency and microwave molecular spectra; (2) paramagnetic resonance; (3) nuclear and quadrupole magnetic resonance. Two of the papers are published elsewhere, abstracts of the remaining 122 will be found under the appropriate headings in this or subsequent issues of Physics Abstracts.

4735 A SENSITIVE SUPERHETERODYNE SPECTROMETER FOR ELECTRON SPIN RESONANCE AT 9300 Mc/s.
G.Schoffa and O.Ristau.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 5, 217-23 (1960). In German.

Design considerations and constructional details of such a spectrometer are given. With oscillographic presentation, the stated sensitivity is sufficient to observe $2.5 \times 10^{-9}$ mole of electron spin. Five times this sensitivity is attainable with slow lock-in registration. J.Sheridan

4736 HOMODYNE BALANCED MIXER ELECTRON SPIN RESONANCE SPECTROMETER. J.C.M.Henning.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 35-40 (Jan., 1961).

A simple electron-spin resonance spectrometer for the detection of organic free radicals is described. The salient features are (1) homodyne balanced mixer detection, (2) improvement of the magnetic field homogeneity by means of two pairs of current shims and (3) new tuning procedure independent of the resonance spectrum itself, makinguseof the klystron-stabilization error signal. At 3200 G the magnetic field homogeneity is better than $2:10^5$ over a sample volume of 0.25 $cm^3$. The sensitivity is such that $2 \times 10^{13}$ spins of the free radical DPPH can be detected.

4737 MOMENT ANALYSIS OF MAGNETIC RESONANCE SIGNALS. P.H.Verdier, E.B.Whipple and V.Schomaker.
J. chem. Phys. (USA), Vol. 34, No. 1, 118-19 (Jan., 1961).

A relation is given between the moments of a generalized convolution transform of a function, and the moments of the function itself. This relation is applied to the signal obtained with a field-modulated e.p.r. spectrometer, a consequence being that the integrated intensity of an absorption line may be obtained from first moment measurements at any modulation amplitude, regardless of line shape or various instrumental nonidealities. This result has been verified experimentally to within a few percent with a Varian e.p.r. spectrometer. Extension to measurement of higher moments is discussed.

4738 STRONG COUPLING IN NUCLEAR RESONANCE SPECTRA. IV. EXACT ANALYSIS OF THREE-SPIN SPECTRA. S.Castellano and J.S.Waugh.
J. chem. Phys. (USA), Vol. 34, No. 1, 295-309 (Jan., 1961).

For Pt. III, see Abstr. 7802 of 1960. A method is developed for calculating the chemical shifts and spin-spin coupling constants for a system of three spin-$\frac{1}{2}$ nuclei (ABC) directly from the nuclear resonance spectrum. Trial-and-error adjustment of these parameters is avoided entirely, and the values obtained are exactly consistent with the input information. The use of experimental intensities is kept separate from that of experimental frequencies, and the former may be omitted entirely when experimental values

fficient accuracy are not available. It is shown that previously own ambiguities in the assignment of parameters sometimes , and that conventional iterative analyses may occasionally o the wrong answer. The proton resonance spectra of four ounds containing vinyl groups are discussed as illustrations e method.

4739 ANALOGUE METHOD FOR COMPUTING THE NUMBER OF SPINS CONTRIBUTING TO A MAGNETIC ONANCE ABSORPTION. V.R.Burgess.
i. Instrum. (GB), Vol. 38, No. 3, 98-9 (March, 1961).
An analogue method is described by which the number of spins ibuting to a magnetic resonance absorption line may be com- from a recorder tracing of the derivative of the line. Since rea under an absorption profile is proportional to the first ent of the algebraic area under its derivative, it may be mined by a simple balance and cardboard cut-outs of the ng.

4740 RADIATION INSTABILITY IN NUCLEAR MAGNETIC RESONANCE EXPERIMENTS. K.V.Vladimirsky.
ear Instrum. (Internat.), Vol. 1, No. 6, 329-30 (Dec., 1957).
The stability of the sample–resonant circuit system in n.m.r. nsidered. The properties of the sample are specified by the macroscopic equations assuming no external r.f. field. The itions for self-excitation are derived which, it is claimed, may ntisfied, for example, in water at accessible field strengths. of the system as a nuclear magnetic oscillator and amplifier w noise is suggested. R.G.C.Arridge

4741 NARROW-BAND MEASUREMENT OF NUCLEAR ABSORPTION LINE WIDTH AND MAGNETIC FIELD DIENT. A.V.Kubarev.
ory i Tekh. Eksper. (USSR), 1958, No. 3, 68-70 (May-June).
ssian.
An examination is made of the features of nuclear resonance rption signals in a narrow-band amplifier when linear and sinusoidal modulations are used. The possibility is indicated of measuring the width of a resonance curve when wide-band modulation is used, and, in principle of making a direct estimate of the field gradient from the line-width. The conclusions are verified by experimental data; the results are compared with measurements of the same quantities from observation of the dispersion curve with narrow-band amplification and narrow-band modulation. [English translation in: Instrum. exper. Tech. (USA), No. 3, 393-5 (May-June, 1958; publ. June, 1959)].

FLOWING-LIQUID PROTON-RESONANCE APPARATUS USING ADIABATIC FAST PASSAGE. See Abstr. 4358

4742 NUCLEAR QUADRUPOLE RESONANCE. V.S.Grechishkin.
Uspekhi fiz. Nauk (USSR), Vol. 69, No. 2, 189-216 (Oct., 1959). In Russian. English translation in: Soviet Physics–Uspekhi (USA), Vol. 2(69), No. 5, 699-718 (Sept.-Oct., 1959).
Systematizes the accumulated theoretical and experimental material in the literature. Current n.q.r. investigations being carried out in the Soviet Union are surveyed. 180 references. [This is the first comprehensive review article on this subject to be produced]. J.M.Baker

4743 RADIO SPECTROSCOPY AND CONTEMPORARY THEORETICAL CHEMISTRY.
L.A.Blyumenfel'd and V.V.Voevodskii.
Uspekhi fiz. Nauk (USSR), Vol. 68, No. 1, 31-49 (May, 1959).
In Russian. English translation in: Soviet Physics–Uspekhi (USA), Vol. 2(68), No. 3, 365-77 (May-June, 1959).
A review of experimental results and theoretical interpretations in four fields of radio spectroscopy. Electron paramagnetic resonance is mainly discussed, but nuclear magnetic resonance, nuclear quadrupole resonance and microwave spectroscopy of gases are briefly surveyed also. There are 45 references, about a third of which are to recent Russian work. J.Sheridan

# NUCLEAR PHYSICS

4744 EXPERIMENTAL NUCLEAR PHYSICS AND RADIOCHEMISTRY. DETECTION OF RADIATIONS AND THODS OF STUDY OF NUCLEAR STRUCTURE.
vaux pratiques de physique nucléaire et de radiochimie. ection des rayonnements et méthodes d'étude de la structure éaire]. M.Duquesne, R.Grégoire and M.Lefort. Appendix by evoret.
is: Masson et Cie. (1960) 324 pp. In French.
This work is intended for students of nuclear physics or nistry at the Faculte de Sciences. The practical and experimental aspects may be of interest also to engineers and technicians desire to acquire an insight into the subject. The experiments ential to the understanding of the techniques of detection of ation and of the investigation of nuclear structure are described ply, preceded by a quite general exposition of the fundamentals uclear physics. The book is in two parts: the first part deals the detection of radiation and the methods in general use for measurement of the intensity and energy of photons, $\alpha$-particles electrons. The application of these in the field of radiochemistry ows in a series of experiments. The second part presents a y of the decay processes of the nucleus. Biological effects of ation and the problems of protection are discussed in the endix. Tables of useful formulae and constants and a series of ked problems together with a short bibliography and index pletes the book. S.J.St-Lorant

COUNTING AND IRRADIATION EXPERIMENTS WITH LINDERS: FORMULA FOR SUBTENDED SOLID ANGLE. See tr. 4171

## APPARATUS
## PARTICLE DETECTORS

*(Counting circuits are included under Electrical Measurements and Circuits)*

4745 HODOSCOPE FOR LOW LEVEL OUTPUT PARTICLE DETECTORS. L.D.Heggie and G.E.Masek.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 193-4 (Feb., 1961).
A scheme of combining a large number of low-level output particle detectors into a hodoscope is described. Features include economy of amplification equipment and a short resolving time against accidental events.

SOME RESULTS OBTAINED IN DEVELOPING A RECORDING GEIGER-COUNTER X-RAY INTENSITY MONITOR. See Abstr. 4686

LARGE IONIZATION COUNTER FOR DETECTION OF WEAK $\alpha$-ACTIVITY. See Abstr. 4842

4746 THE NONUNIFORMITY OF LIGHT GATHERING IN LARGE SCINTILLATORS. V.F.Grushin and A.N.Zinevich.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 29-31 (March-April).
In Russian.
A method is described which permits to diminish to ±12% the maximum deviation from the mean of the amount of light falling on a photomultiplier due to flashes occurring in different parts of the scintillator. The equipment comprises a plastic scintillator in the form of a circular disk (radius 50 mm, thickness 10 mm), a transparent light guide, and a photomultiplier. [English translation in: Instrum. exper. Tech. (USA), No. 2, 205-7 (March-April, 1958; publ. April, 1959)]

4747 HIGH RESOLUTION FOCUSING ČERENKOV DETECTOR FOR HIGH ENERGY PARTICLES. D.A.Hill, D.C.Caldwell, D.H.Frisch, L.S.Csborne, D.M.Ritson and R.A.Schluter.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 111-17 (Feb., 1961).

A focusing differential Cherenkov counter of high velocity resolution using a gas radiator has been developed and used in relativistic particle beams. The optical and mechanical features are described. The velocity $\beta$ can be varied continuously from 0.81 to 1.00. These counters give a velocity resolution $\Delta\beta/\beta$ of 0.0025 (half-width at half-maximum) at $\beta = 0.9985$ and an average efficiency for a 4 in. diameter particle aperture of 0.7 in a particle beam collimated to $\pm 1^0$. The sources response and the ultimate limitations of counters of this type are discussed.

4748 ELECTROSTATIC ANALYSER FOR STUDYING ANGULAR DISTRIBUTIONS OF CHARGED PARTICLES OF NUCLEAR REACTIONS. V.F.Litvin.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 32-4 (May-June). In Russian.

Design calculations are given for an analyser in which second-order focusing is achieved over a wide energy range ($\Delta\epsilon/\epsilon \cong 200\%$) by extracting the particles from the field of a plane condenser through one of the plates of the condenser. The geometric focusing line is inclined with respect to the condenser plates at an angle of $10^0 54'$. The relation between the energy of the focused particle and the coordinate on the focal line is linear. Because of the azimuthal symmetry of the problem it is possible to obtain a theoretical transmission of $\Omega = 0.33$ ster with a resolving power of $R \cong 10^3$. [English translation in: Instrum. exper. Tech. (USA), No. 3, 351-3 (May-June, 1958; publ. June, 1959)].

# Track Visualization

4749 LOW-TEMPERATURE BUBBLE CHAMBERS. N.C.Barford.
Progress in cryogenics, Vol. 2 (see Abstr. 4509 of 1961) p. 87-119.

The theory and design of low-temperature bubble chambers, mainly using liquid hydrogen, is discussed. The track formation, generation of bubbles, bubble growth time, operating conditions and track measurements, are described. Various methods of temperature control and different expansion systems are considered. The special illumination and photographic techniques required are reviewed. 47 refs. J.B.Birks

4750 THE INTRODUCTION OF HYDROGEN AND DEUTERIUM INTO AN EMULSION. T.A.Romanova.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 21-4 (March-April). In Russian.

A method of introducing these elements into an emulsion in the form of a stable hydrogenous compound has developed, which enables one to bring the hydrogen content up to $0.6 \times 10^{23}$ nuclei/cm$^3$ and to introduce $0.3 \times 10^{23}$ deuterium nuclei into 1 cm$^3$ of the dry emulsion. [English translation in: Instrum. exper. Tech. (USA), No. 2, 197-9 (March-April, 1958; publ. April, 1959)].

NUCLEAR TRACK EMULSIONS FOR THE STUDY OF PROTONS. See Abstr. 4751

4751 THE MEASUREMENT OF THE IONIZATION OF FAST PARTICLES IN THE NUCLEAR EMULSION R-NIKFI. N.M.Viryasov and L.P.Pisareva.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 17-21 (March-April): In Russian.

The possibility of making quantitative measurements of ionization in emulsions using calibrating tracks is investigated for work on accelerators. The number of grains per unit length of trace for protons of energies 148, 198, 250, 302, 464 and 657 MeV and for $\pi$-mesons of 360 MeV is compared with the theoretical value for the relative ionization losses. It is established that there is a region of ionization in which the experimental data agree with the theoretical values to within a few percent. For regions of greater ionization, methods of introducing a correction based on the use of the parameter d, which plays the role of an effective grain size, are suggested. A simple geometric calculation to take into account the inclination of the trace is tested and a method of introducing the corresponding corrections indicated. [English translation in: Instrum. exper. Tech. (USA), No. 2, 191-6 (March-April, 1958; publ. April, 1959)].

# NUCLEAR FIELD THEORY

SOLUTION OF THE COMBINED GRAVITATIONAL AND MES FIELD EQUATIONS IN GENERAL RELATIVITY. See Abstr. 425

4752 ON THE SUBSTITUTION LAW IN QUANTUM FIELD THEORY. D.Judge, H.Shimodaira and Y.Takahashi.
Proc. Roy. Irish Acad. A, Vol. 61, No. 6, 45-54 (Jan., 1961).

The validity of the substitution law proposed by Jauch and Rohrlich (1955) is examined for quantum field theory in general, without recourse to perturbation expansion. A general condition the interaction Hamiltonian is obtained for the S-matrix to satisfy this law. It is pointed out that the general condition is satisfied local operator in the sense of Bogolyubov–Shirkov. The applica of the Lehmann–Symanzik–Zimmermann formulation (Abstr. 15 1955) to the discussion of the substitution law is considered, usin as an example the Lee model in Lagrangian form.

4753 HAMILTONIAN FORMALISM AND THE CANONICAL COMMUTATION RELATIONS IN QUANTUM FIELD THEORY. H.Araki.
J. math. Phys. (USA), Vol. 1, No. 6, 492-504 (Nov.-Dec., 1960).

Cyclic representations of the canonical commutation relation for a self-interacting neutral scalar field and their connection wi the Hamiltonian formalism are studied. The vacuum expectation functional $E(f) = (\Psi_0, e^{i\varphi(f)}\Psi_0)$ turns out to be a very convenient t for the discussion. The uniqueness of a translationally invariant state (vacuum) is proved under the assumption of the cluster dec position property for E(f). The existence and near uniqueness of the Hamiltonian in cyclic representations of the canonical commu tion relations are established. The conditions for the relativistic invariance of the theory are stated in terms of vacuum expectatio values at a fixed time. It is shown that E(f) is the Fourier trans form of a quasi-invariant nonnegative measure on the space of al linear functionals of the test functions.

4754 RELATIVISTIC MODEL FIELD THEORY WITH FIN SELF-MASSES. F.Zachariasen.
Phys. Rev. (USA), Vol. 121, No. 6, 1851-61 (March 15, 1961).

A model field theory is invented in the following way: disper relations in the energy are assumed to hold for all amplitudes; unitary gives the absorptive parts in the "physical" regions. If it is assumed that the absorptive parts are otherwise zero (in viola of crossing symmetry and the Mandelstam representation), then dispersion relations and unitarity form an infinite set of coupled integral equations for all amplitudes. An exact solution (at least for the simplest amplitudes) to this set of equations can be found in which all self-masses, etc., are finite. The solution is equiv alent to summing a certain class of Feynman graphs, computed i the usual way. For a wide range of coupling constants, there are no "ghost" difficulties.

4755 GENERALIZED RETARDED FUNCTIONS AND ANALYTICAL FUNCTION IN MOMENTUM SPACE IN QUANTUM FIELD THEORY. H.Araki.
J. math. Phys. (USA), Vol. 2, No. 2, 163-77 (March-April, 1961).

The analytic n-point function in momentum space in quantum field theory is studied. Its different boundary values for real val of the argument are determined, and a necessary and sufficient condition for them to be obtainable from the Wightman functions is given. The conditions are relativistic covariance, support pro perties in coordinate space (retardedness), two-term identities f momentum below threshold (corresponding to spectrum condition and four-term identities (Steinmann relations). The first three c ditions are translatable into a statement about the domain of anal icity of then-point function: it is analytic in a union of various extended tubes plus the points of contact of two neighbouring tube for real part of one momentum below threshold.

4756 COMPLEX ORTHOGONAL AND ANTIORTHOGONAL REPRESENTATION OF LORENTZ GROUP. B.Kursunoğlu.
J. math. Phys. (USA), Vol. 2, No. 1, 22-32 (Jan.-Feb., 1961).

By using the fact that a plane electromagnetic wave is descr by two Lorentz invariant statements, a complex orthogonal repre sentation of the Lorentz group, including charged fields, is dis- cussed. The representation provides the possibility of a combin study of the P, C, T symmetry operations for spin-$\frac{1}{2}$ and spin-1

s. In particular, the chargelessness of the neutrino as a lex fermion field results from a reducible three charge states esentation of the complex group.

4757 SYNTHETIC APPROACH AND CANONICAL VARIABLES IN A NONLOCAL FIELD THEORY.
ni.
ath. Phys. (USA), Vol. 2, No. 1, 46-51 (Jan.-Feb., 1961).
The analysis of the axiomatic structure of quantum field y establishes what is called the synthetic approach. The slation in time is completely defined by its transformation ion; it defines also canonical variables. The Hamiltonian is ssed at a later stage in order to establish the correspondence een this approach and the conventional one. An application is to analyse Kristensen–Moller's theory of a nonlocal field. eld variables are shown to be noncanonical; two field operators rring to two different points at the same time are not indepen- from each other, when the distance between the two points is e order of the extension of the form factor; however, this fact not disturb the calculation of the S matrix. The situation is rly understood when the Kristensen–Moller field operators are pared with the corresponding canonical variables.

SCHWARTZ DISTRIBUTIONS IN QUANTUM FIELD THEORY.
Abstr. 4177

4758 QUANTIZATION OF NONLINEAR SYSTEMS. I.E.Segal.
ath. Phys. (USA), Vol. 1, No. 6, 468-88 (Nov.-Dec., 1960).
A direct method of quantization, applicable to a given nonlinear rbolic partial differential equation, is indicated. From such sical equations alone, without a given Lagrangian or Hamiltonian, priori linear reference system such as a bare or incoming field, antized field is constructed, satisfying the conventional mutation relations. While mathematically quite heuristic in , local products of quantized fields do not intervene, and there grounds for the belief that the formulation is free from nontrivial rgences.

4759 QUANTIZATION OF FIELDS WITH INFINITE-DIMENSIONAL INVARIANCE GROUPS. B.S.DeWitt.
ath. Phys. (USA), Vol. 2, No. 2, 151-62 (March-April, 1961).
A general approach to the problems of quantizing fields which e infinite-dimensional invariance groups is given. Space and e are treated on a completely equal footing. A Poisson bracket efined by means of Green's functions, independently of the dis- ery or recognition of canonical variables, and is shown to satisfy the usual identities. In accordance with the measurement theore- l fundations of the quantum theory, the Poisson bracket (i.e., mutator) is defined only for physically measurable group ariants. The Green's functions give a direct description of the pagation of small disturbances arising from a pair of mutually rfering measurements. In order to establish a correspondence ween this approach and conventional canonical theory, a motiva- n for the adopted definition of the Poisson bracket is outlined with aid of the fundamental theorem of canonical transformation ory. The rest of the discussion is logically independent of this, vever. The general theory of "wave operators" and their asso- ted Green's functions is briefly reviewed. Specific details nected with the group-theoretical side of the theory and handled such a way that problems of constraints are completely avoided. he last section the general method is applied to the Yang–Mills d, as a nontrivial example. The problem of factor ordering is studied.

4760 ASYMPTOTIC PROPERTIES OF A BOSON FIELD WITH GIVEN SOURCE. J.M.Cook.
math. Phys. (USA), Vol. 2, No. 1, 33-45 (Jan.-Feb., 1961).
Some mathematical questions are answered in the theory of ntized boson fields with given linear source distribution. It is ved that the total Hamiltonian in the Fock representation is f-adjoint. Unitary operators governing the evolution of the sys- n in the interaction picture are defined, and conditions given for ir weak and strong convergence at remote times.

4761 ASYMPTOTIC CONDITIONS IN QUANTUM ELECTRODYNAMICS. L.E.Evans and T.Fulton.
clear Phys. (Internat.), Vol. 21, No. 3, 492-507 (Dec. (1), 1960).
The applicability to quantum electrodynamics of the asymptotic nditions of Lehmann, Symanzik, and Zimmerman (LSZ) is con- ered.(Abstr. 1510 of 1955). The Coulomb gauge formulation of the theory is examined and it is shown that the LSZ formalism can be used with this form, but not with the Lorentz gauge form. Formal aspects of the renormalization programme in the Coulomb gauge are discussed. It is found that the renormalization of the electron requires momentum-dependent factors, and hence that the renormalized electron field violates local commutativity. The S-matrix is briefly discussed. To illustrate charge renormalization, a calculation of the charge of the state of a single electron is given.

4762 USE OF THE DISPERSION METHOD FOR INVESTIGATION OF THE SIMPLEST GREEN'S FUNCTIONS IN QUANTUM ELECTRODYNAMICS. V.D.Mur and V.D.Skarzhinski.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1817 23 (June, 1960). In Russian.
The dispersion relations approach is used to study the electron propagation function $G(\hat{p})$ and current matrix element $\langle 0|\eta(0)|\ p'k\rangle$ as functions of $p^2 = (p' + k)^2$. It is shown that in the two-particle approximation (no more than two particles in the intermediate state) the analytical properties of the matrix element with respect to the variable $p^2$ lead to a Hilbert boudary problem which is then solved. Explicit expressions for the electron propagation functions are derived and the asymptotic behaviour of $G(\hat{p})$ and $\Gamma\mu(p, p'; k)$ for $-p^2 \to \infty$, $p'^2 = -m^2$ and $k^2 = 0$ is determined. [English translation in: Soviet Physics–JETP (USA), Vol. 11, No. 6, 1308-11 (Dec., 1960)].

4763 KEMMER WAVE EQUATION IN RIEMANN SPACE. A.da Silveira.
J. math. Phys. (USA), Vol. 1, No. 6, 489-91 (Nov.-Dec., 1960).
The Kemmer wave-equation for spin-zero and spin-one particles (Abstr. 4466 of 1939) is written in Riemann space. The form of the equation, the supplementary relations and the form of the covariant derivatives of the operators $\beta^\mu$ are considered. As a check of the equation it is shown that the equations for the values zero and one of the spin can be obtained from this generalized Kemmer equation with the help of generalized Fujiwara operators. In particular the equation for photons in interaction with the gravitational field is obtained.

4764 "FRONT" DESCRIPTION IN RELATIVISTIC QUANTUM MECHANICS. R.Acharya and E.C.G.Sudarshan.
J. math. Phys. (USA), Vol. 1, No. 6, 532-6 (Nov.-Dec., 1960).
The problem of introducing a Cartesian position operator canonically conjugate to the momentum operator into relativistic one-particle theories is investigated independent of any particular relativistic wave equation. The known result that such a description is possible for particles with nonvanishing mass is rederived. The general problem of introduction of canonical variables into relativistic theories is formulated and solved. The configurational indices so obtained correspond to directed plane wavefronts rather than point particles.

4765 UNIFIED APPROACH TO HIGH- AND LOW-ENERGY STRONG INTERACTIONS ON THE BASIS OF THE MANDELSTAM REPRESENTATION. G.F.Chew and S.C.Frantschi.
Phys. Rev. Letters (USA), Vol. 5, No. 12, 580-2 (Dec. 15, 1960).
It is postulated that the double spectral functions in the strips lying between the two boundary curves in any particular non-physical sector of the Mandelstam diagram dominate the amplitudes in the nearby regions of the physical sectors; the spectral functions in the strip zones are given exactly by integrals over bilinear combinations of absorptive parts of elastic amplitudes. This provides a theory which is applicable not only to low energies but also to arbitrarily high energies involving low momentum transfer. The constancy of high-energy total cross-sections then implies that at low energies there is a strong interaction only in P-waves. P.K.Kabir

4766 SOME CONSEQUENCES OF THE SYMMETRY OF THE UNIVERSAL WEAK FERMI INTERACTION.
Khe Tszo-syu [Ho Tso-hsiu] and Chzhu Khun-yuan' [Chu Hung-yuan].
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1872-8 (June, 1960).
In Russian.
It is shown that the invariance of the universal weak V–A Fermi interaction with respect to the Fierz transformation forbids the $\mu$-meson being captured by the proton in the triplet S state. It also forbids the $\mu$-meson being captured by the proton in the singlet S state with the emission of one photon. It is shown further that the state of two fermions or that of two antifermions produced in all weak interaction processes can be described by one wave-function, if the effects of other interactions involving these two particles are neglected. In particular, the general functions describing the

polarization correlation are given. The asymmetry in the angular distribution of the neutron emitted by a nucleus capturing a $\mu$-meson is discussed. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1346-50 (Dec., 1960)].

4767 SMALL BINDING ENERGIES IN QUANTUM FIELD THEORY. L.D.Landau.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 6(12), 1856-7 (Dec., 1960). In Russian.

It is shown that for weakly bound (but strongly interacting) particles there is a direct connection between the binding energy and the "coupling constant" characterizing the combination of the two particles into a compound one. [English translation in: Soviet Physics—JETP (USA)]. R.F.Peierls

EFFECTS OF THE WEAK INTERACTION ON THE HYDROGEN ENERGY LEVELS. See Abstr. 4899

4768 ELASTIC AND INELASTIC SCATTERING CROSS-SECTIONS. J.W.Albrecht.
An. Real Soc. Espan. Fis. Quim. (Spain), Vol. 55, No. 7-8, 223-6 (July-Aug., 1959).

The two-body scattering problem is considered and scattering is described as usual in terms of the S-matrix whose elements are the probability amplitudes for transitions from the initial channel to the final channels. Simple expressions are derived for the integrated elastic and inelastic cross-sections, and these are seen to depend on the same matrix elements of S. J.F.Hill

4769 ON THE STRUCTURE AND PARITY OF WEAK INTERACTION CURRENTS. F.Gürsey.
Ann. Phys. (USA), Vol. 12, No. 1, 91-117 (Jan., 1961).

The formulation of weak interactions by means of a current interacting with itself is generalized to the case in which $T = \frac{3}{2}$ currents also exist, assuming the $\Delta T = \frac{1}{2}$ rule to be valid. Furthermore, generalizing the Feynman–Gell-Mann theory, it is postulated that all the currents entering the weak interactions are conserved in the limit of meson masses and baryon mass differences being neglected. This restriction limits the isotopic spin of the currents to $T = \frac{1}{2}$, 1, and $\frac{3}{2}$ if $S = 2$ currents are excluded. Another consequence of the same hypothesis is that parity mixtures are allowed for the $T = \frac{1}{2}$ and $T = 1$ currents, but not for the $T = \frac{3}{2}$ current. The five types of currents thus obtained (V and A currents with $T = \frac{1}{2}$, 1 and only V or A with $T = \frac{3}{2}$) can be combined into a $4 \times 4$ matrix current $\mathfrak{J}_\chi$. It is shown that a weak Lagrangian proportional to the trace of $\mathfrak{J}_\lambda^\dagger \mathfrak{J}_\lambda$ satisfies the $\Delta T = \frac{1}{2}$ rule. In the absence of neutral lepton currents the charged lepton current is necessarily incorporated in a rather unsymmetrical manner, but in conformity with the $\Delta T = \frac{1}{2}$ rule in strangeness changing leptonic decays. The scheme is applied to the decay of $\Sigma$ hyperons. In the pionic decay of $\Sigma^+$, and in the lowest order in strong interactions, parity is conserved in the channel $\Sigma^+ \to n + \pi^+$ and violated in the channel $\Sigma^+ \to p + \pi^0$ if all the five types of current are present. The phenomenological Lagrangian of Bludman (Abstr. 13578 of 1959) for $\Sigma$ decay is obtained as a direct interaction from the terms of the weak Lagrangian. A model of a baryon–meson nonlinear interaction generalizing a previous model is given in which all the five types of conserved currents are shown to exist.

4770 APPROXIMATE SOLUTIONS OF THE BETHE–SALPETER EQUATION. S.H.Vosko.
J. math. Phys. (USA), Vol. 1, No. 6, 505-15 (Nov.-Dec., 1960).

A modified representation of the Bethe–Salpeter wave-function for scalar particles interacting via a massless scalar field is presented and related to Salpeter's approximate wave-function. A procedure for obtaining approximate solutions of the Bethe–Salpeter equation for arbitrary interactions is introduced. The method is based on a variational principle and is capable of high accuracy when used with the trial functions developed here. The choice of trial function is suggested by the important features of the exact solutions for the special case described above. The method is applied to a finite range potential which corresponds to the lowest order approximation to a simple field theory. The results of the calculation suggest that the effect of retardation is large when an interaction is transmitted by a field with mass.

4771 RECURRENT CONSTRUCTION OF ANGULAR OPERATORS. I.
Ya. Fisher [J.Fischer] and S.Chulli [S.Ciulli].
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1740-50 (June, 1960). In Russian.

Gives a practical recurrent method for construction of angular operators which characterize the angular and spin dependences of the S-matrix. Only differential operations are employed and the Racah transformations and calculations involving the Clebsch–Gordan coefficients can be avoided. The method permits one to find the angular operators of a given process providing the angular operators of a simpler process providing the angular operators of a simpler process are known. A solution is given of the problem of how a set of angular operators will change if one initial and one final scalar particles are replaced by spin $\frac{1}{2}$ particles. Practical formulae and examples are presented. [English translation in: Soviet Physics—JETP (USA), Vol.11, No. 6, 1256-2 (Dec., 1960)].

4772 ANALYTICAL PROPERTIES OF S MATRIX AND UNIQUENESS OF THE SCATTERING POTENTIAL.
A.O.Barut and K.H.Ruei.
J. math. Phys. (USA), Vol. 2, No. 2, 181-7 (March-April, 1961).

The Schrödinger equation with the complex momentum k leads to an S matrix with very simple analytical properties. It differs from the conventional S matrix as little as one wishes on the real k axis, but it has, in general, completely different analytical behaviour outside the real axis. The present formulation removes some of the unsatisfactory features of the conventional formalism in the sense that no redundant poles can occur and a phase shift determines the scattering potential uniquely. The complete analytical behaviour of the S matrix, in particular at infinity, is discussed and the theory is extended to Klein–Gordon and Dirac equations with central potential.

4773 STRUCTURE OF THE MANY-CHANNEL S MATRIX. R.C.Newton.
J. math. Phys. (USA), Vol. 2, No. 2, 188-97 (March-April, 1961).

Considers the nonrelativistic elastic and inelastic scattering of two particles with internal degrees of freedom, or reactions giving rise to two particles. It is shown under very general conditions that all elements of the S matrix can be simply obtained from a single analytic function of all channel momenta, the Fredholm determinant of the scattering and reaction integral equations. Its properties are investigated and the restrictions are established which are necessary and sufficient in order to assure that the unitarity condition is fulfilled. The square well and a superposition of Yukawa potentials are considered as examples.

4774 THE THEORY OF MULTIPLE SCATTERING THROUGH SMALL ANGLES. H.Fleischmann.
Z.Naturforsch. (Germany), Vol. 15a, No. 12, 1090-6 (Dec., 1960). In German.

Corrections to some of the assumptions underlying Molière's formula are calculated. W.A.Hepner

4775 PRODUCTS OF PRINCIPAL VALUE SINGULARITIES USED IN THE FORMAL THEORY OF SCATTERING. S.Tani.
J. math. Phys. (USA), Vol. 2, No. 2, 198-201 (March-April, 1961).

A mathematically neat derivation is given of the relation between the S matrix and the transformation function for a finite time. It is shown that one can dispense with the adiabatic switching on and off and yet one reaches the same result as when one employs it. Necessary conditions are discussed for the validity of this statement. Systematic prescriptions are given of handling products of principal value singularities, which is relevant to the scattering theory in momentum space.

4776 RENORMALIZATION PROBLEM FOR VECTOR MESON THEORIES. A.Komar and A.Salam.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 624-30 (Dec. (3), 1960).

The renormalizability problem of the Yang–Mills theory of vector mesons with mass is considered. It is shown that the divergences of such a theory are those of the electrodynamics of charged vector mesons. This general feature is illustrated by direct calculation of the lowest order divergent diagrams. It is concluded that renormalizability of this theory seems rather unlik

4777 USE OF THE DISPERSION APPROACH IN INVESTIGATION OF THE SIMPLEST GREEN'S FUNCTIONS IN MESON DYNAMICS. V.V.Malakhov, E.P.Rashevskaya and V.Ya.Fainberg.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1803-13 (June, 1960). In Russian.

An approximate set of dispersion equations for the meson and nucleon Green's functions and the vertex function is investigated in pseudoscalar charge-symmetrical meson dynamics. The

iptotic behaviour of these functions, which corresponds to ite values of $Z_2^{-1}$ and $Z_3^{-1}$, is deduced in the case of weak ling. [English translation in: Soviet Physics—JETP (USA), 11, No. 6, 1298-1305 (Dec., 1960)].

4778 VARIATIONAL PRINCIPLES FOR NON-STATIONARY QUANTUM-MECHANICAL PROBLEMS AND PERTURION THEORY. Yu.N.Demkov.
eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1879-86 (June, 1960).
ıssian.
A variational principle is formulated which is invariant with ect to normalization of wave-functions and which can be used in ase of non-orthogonal wave-functions of the initial and final s. The problem of uniqueness of perturbation theory in this is considered. The possibility of employing the variational ciple for solution of problems concerning decay of the quasi-onary state and charge exchange is discussed. The main tions for charge exchange at large impact parameters are ved from the variational principle. [English translation in: et Physics—JETP (USA), Vol. 11, No. 6, 1351-5 (Dec., 1960)].

4779 DETERMINATION OF THERMODYNAMIC GREEN'S FUNCTIONS. G.Baym and N.D.Mermin.
ath. Phys. (USA), Vol. 2, No. 2, 232-4 (March-April, 1961).
In the study of thermodynamic correlation functions or Green's tions used in quantum-mechanical many-body problem, one is rally led to a calculation of values of the Fourier transform of Green's function on a discrete set of points in the complex gy plane. It is shown that even though these points do not in eral possess a limit point within the region of analyticity, one still uniquely determine the Fourier transform of the Green's tion directly from its values at these points.

4780 THE MOMENTUM DISTRIBUTION IN A DILUTE FERMI GAS AT ZERO TEMPERATURE.
żyz and K.Gottfried.
ear Phys. (Internat.), Vol. 21, No. 4, 676-80 (Dec. (3), 1960).
The momentum distribution at zero temperature in a dilute mi gas with repulsive interactions is calculated to second order ie small parameter $p_F a$, the quantity $p_F$ being the Fermi ientum, and a the free-space scattering length.

QUANTUM-MECHANICAL MANY-BODY PROBLEM, CHASTIC APPROACH. See Abstr. 4267

# ELEMENTARY PARTICLES

4781 UNDISCOVERED PARTICLES. I.
P.Renson.
. Acad. Roy. Belgique Cl. Sci., Vol. 46, No. 6, 468-74 (1960). In nch.
The possible existence of undiscovered elementary particles is ussed. The electric charge Q and the "neutrinonic charge" R, oduced previously (Abstr. 15308 of 1960) are given for two such icles, which are baryons: Q = 1, R = 0 and Q = −1, R = -2; for D-meson, they are Q = 1, R = 1.

4782 UNDISCOVERED PARTICLES. II.
P.Renson.
. Acad. Roy. Belgique Cl. Sci., Vol. 46, No. 7, 609-20 (1960). In nch.
The X and Y particles predicted in Pt I have, presumably, ses of about 2150 and 2900 e.m., respectively. They may decay pectively into a nucleon and a Ξ-hyperon by emitting a pion; life-es of the order of $10^{-10}$ sec may be expected (weak interactions). mass of the D-meson is about 1670 e.m. and it decays into a eson and one or two pions. Leptonic modes of decay are also sible. The dimension 3 of the charge-space (Abstr. 15308 of 1960) onfirmed. The correlations considered in that paper are re-mined.

4783 A MODEL FOR LEPTONS. THE ELECTRON—MUON AND NEUTRINO FIELDS. K.H.Tzou.
. Acad. Sci. (France), Vol. 251, No. 23, 2659-61 (Dec. 5, 1960).
rench.
A model is proposed for a description of the electron and muon constituting a mass doublet, with masses $m_1$ and $m_2$. The definition is made in such a way that eigenstates of the mass reversal operator M, with eigenvalues ±1 correspond to the states with masses $m_1 \pm m_2$ and these are supposed to correspond to the physically observed particles. An analogous discussion for the case of $m_1 \pm m_2 = 0$ predicts the existence of two neutrinos, associated with electron and muon process respectively.
R.F.Peierls

4784 A MODEL FOR LEPTONS. ELECTROMAGNETIC AND WEAK INTERACTIONS. K.H.Tzou.
C.R. Acad. Sci. (France), Vol. 251, No. 25, 2895-7 (Dec. 19, 1960). In French.
The electromagnetic and weak interactions are introduced into the lepton model discussed previously (see preceding abstract). The electron—muon current looks exactly like the lepton current in the theory of weak interactions. The four-component neutrino theory is necessary for mass reversal symmetry and the electron and muon neutrinos turn out to have opposite helicities.
R.F.Peierls

4785 SIGN CONVENTION FOR PARTICLE POLARIZATION. Nuclear Phys. (Internat.), Vol. 21, No. 4, 696 (Dec. (3), 1960).
Reports the "Basle sign convention" for incident and outgoing particles, agreed to at the recent International Symposium on Polarization Phenomena of Nucleons held in Basle.

# Photons

4786 THE ELASTIC γp-SCATTERING AT 40-70 MeV AND THE POLARIZABILITY OF THE PROTON.
V.I.Gol'danskii, O.A.Karpukhin, A.V.Kutsenko and V.V. Pavlovskaya. Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1695-1707 (June, 1960). In Russian.
The elastic γp-scattering at 40-70 MeV energy was investigated and differential cross-sections at 45, 75, 90, 120, 135 and 150° were determined. The results were compared with the theory which takes into account the anomalous proton magnetic moment as well as the effects of mesonic cloud polarization. The cross-section of the γp-scattering at 90° corresponds to a proton-electric polarizability $\alpha_E = (11 \pm 4) \times 10^{-43}$ cm$^3$. The experimental results were supplemented by dispersion relations, which allow one to obtain (from the π-photoproduction data) the sum of the electric ($\alpha_E$) and magnetic ($\alpha_M$) polarizabilities of the proton: $\alpha_E + \alpha_M = 11 \times 10^{-43}$ cm$^3$. Taking this value into account the experimental data yielded the following values of the proton polarizabilities:

$$\alpha_E = (9 \pm 2) \times 10^{-43} \text{ cm}^3, \quad \alpha_M = (2 \mp 2) \times 10^{-43} \text{ cm}^3.$$

A r.m.s. fluctuation of the proton electric-dipole length $(r^2)^{1/2} = (3.5 \sim 5) \times 10^{-14}$ cm corresponded to the quoted electric polarizability. [English translation in: Soviet Physics — JETP (USA), Vol. 11, No. 6, 1223-32 (Dec., 1960)].

4787 SOME PROBLEMS ON THE THEORY OF CRYSTAL DIFFRACTION γ-SPECTROMETERS. O.I.Sumbaev.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 27-31 (May-June). In Russian.
An analysis is given of certain parameters of spectrometers of the Dumond type (Abstr. 345 of 1948; 1084 of 1953), taking account of the effect of curving the reflecting plane of the bent crystal. It is shown that theoretical calculations of the line width agree well with the experimental width. The effect is considered of the thickness and radius of curvature of the bent crystal on the efficiency and resolving power of the spectrometer. [English translation in: Instrum. exper. Tech. (USA), No. 3, 346-50 (May-June, 1958; publ. June, 1959)].

4788 BREMSSTRAHLUNG AT THE BOUNDARY OF A MEDIUM WITH AN ALLOWANCE FOR MULTIPLE SCATTERING.
I.I.Gol'dman.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1866-9 (June, 1960). In Russian.
An investigation is carried out of the composition of bremsstrahlung appearing at the boundary of a medium with an allowance for the Landau—Pomeranchuk—Migdal effect. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1341-3 (Dec., 1960)].

4789 BREMSSTRAHLUNG SPECTRUM FROM THE SCATTERING OF NON-RELATIVISTIC ELECTRONS BY A SCREENED COULOMB FIELD. T.Tietz.
Acta phys. Hungar., Vol. 12, No. 2, 189-92 (1960). In German.

Sauter's formula is applied with a Thomas–Fermi function of the form of a sum of three exponentials. W.A.Hepner

4790 CHERENKOV RADIATION OF DIPOLE MOMENTS IN A MEDIUM WITH SPATIAL DISPERSION.
G.A.Begiashvili and É.V.Gedalin.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1738-9 (June, 1960). In Russian.

Cherenkov radiation from electric and magnetic dipoles in an isotropic non-gyrotropic medium with spatial dispersion is considered. Cherenkov radiation from a ring current in such a medium is also discussed. [English translation in: Soviet Physics – JETP (USA), Vol. 11, No. 6, 1254-5 (Dec., 1960)].

CHERENKOV RADIATION IN OPTICALLY ANISOTROPIC MEDIA. See Abstr. 4424

# Electrons

4791 ASYMMETRY IN DOUBLE MOTT SCATTERING AND THE VALUE OF LONGITUDINAL POLARIZATION OF β-ELECTRONS.
P.E.Spivak, L.A.Mikaélyan, I.E.Kutikov and V.F.Apalin.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 5(11), 1479-81 (Nov., 1960). In Russian.

Previous measurements of longitudinal polarization of β-electrons showed values about 12% smaller than v/c, this estimate depending in part on the method of calculation. The present double-scattering experiment removes this dependence. The results reported are for scattering 245 and 290 keV electrons at 120° from two gold targets. The depolarization was also measured and did not differ significantly from the scattering asymmetry. Revised estimates of the longitudinal polarization of β-electrons are 5% higher, so the deviation from v/c is, for example 7% for $In^{114}$. The absolute error is ±3.3% in this case. [English translation in: Soviet Physics–JETP (USA)]. D.W.L.Sprung

TIME SPECTRA OF POSITRONS ANNIHILATING IN ORGANIC LIQUIDS CONTAINING HALOGENS. See Abstr. 4363

# Nucleons

4792 HIGH-ENERGY NUCLEON–NUCLEON COLLISIONS. F.Salzman and G.Salzman.
Phys. Rev. (USA), Vol. 121, No. 5, 1541-4 (March 1, 1961).

The single virtual-boson exchange interaction model is applied to high-energy inelastic nucleon–nucleon collisions over an energy range of several orders of magnitude. The phase space is discussed simply in terms of three "natural" phase-space variables, and a simple, exact formula is given for the "upper" boundary of these variables. The probability for a particular final-state configuration is then discussed in terms of the available phase space, the magnitude of the phase-space factor, and the magnitude of the average total "cross-section" factors that occur in this model. Qualitative features of experimental data for incident nucleon laboratory energies of 10, $10^2$, and $10^3$ BeV can be understood on the basis of this model.

4793 n–p POLARIZATION AND LOW ENERGY p–p PHASE SHIFTS. R.J.N.Phillips.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 686-7 (Dec. (3), 1960).

It is argued that n–p polarization at 90° c.m. depends only on T = 1 phase shifts to a fair approximation, over a range of low energies. Assuming charge independence, this helps to determine p–p phase shifts.

4794 USEFULNESS OF POLARIZED TARGETS AND THE POLARIZATION TRANSFER TENSOR IN RECONSTRUCTION OF THE NUCLEON–NUCLEON SCATTERING MATRIX. C.R.Schumacher and H.A.Bethe.
Phys. Rev. (USA), Vol. 121, No. 5, 1534-41 (March 1, 1961).

A method is presented for completely removing the ambiguities arising in the reconstruction of the nucleon–nucleon scattering matrix from data at a given angle and energy due to the bilinear form of expressions for observable quantities. The method utilizes only the amplitudes defined by Wolfenstein and Ashkin (Abstr. 413 of 1952; 3090 of 1955) and is more direct and computationally simpler than the methods using unitarity and measurements at all angles or the phase-shift analyses; thus, it would provide an independent means of arriving at the correct set of phase-shift solutions. The method is based on a knowledge of the polarization transfer tensor $\mathcal{K}_{ik}$, which has a form complementary to the familiar polarization correlation tensor $\mathcal{C}_{ik}$. The $\mathcal{K}_{ik}$ tensor may be obtained from triple scattering experiments on the recoil nucleon similar to those used to determine the familiar depolarization tensor $\mathcal{D}_{ik}$, or from double scattering measurements on nucleons scattered from a polarized target. It is also shown that the use of polarized targets would have many experimental advantages: they would permit: (1) determination of the depolarization tensor $\mathcal{D}_{ik}$ for large scattering angles, without requiring the measurement of the polarization of a very slow nucleon; (2) determination of the correlation tensor $\mathcal{C}_{ik}$ by the measurement of the cross-section for the scattering of a polarized beam by a polarized target, instead of the difficult simultaneous measurements of the polarizations of both the final nucleons; (3) determination of the "difficult" components A' and R' of the $\mathcal{D}_{ik}$ and $\mathcal{K}_{ik}$ tensors by the measurement of the polarization of an initially unpolarized beam scattered by a polarized target.

# Protons

4795 LOW-ENERGY p–p SCATTERING PHASE SHIFTS AN DISPERSION RELATIONS. Riazuddin.
Phys. Rev. (USA), Vol. 121, No. 5, 1509-12 (March 1, 1961).

Nucleon–nucleon dispersion relations are used to discriminate among various sets of solutions given by MacGregor (Abstr. 7260 1959) for low-energy proton–proton scattering. This greatly reduces the ambiguity existing the phase-shift analysis at low energ

THE POLARIZABILITY OF THE PROTON. See Abstr. 4786

4796 ANALYSIS OF K-MESON PRODUCTION BY $\bar{p}$ ANNIHILATION. T.F.Hoang.
Phys. Rev. (USA), Vol. 121, No. 5, 1523-4 (March 1, 1961).

K-meson production by $\bar{p}$ annihilation is investigated using an isobar model. A comparison of the predictions of this model with the experimental data excludes the assumption of an isobar state of $(\pi\pi)$ having a mass greater than three pion masses.

4797 ANTIPROTON ANNIHILATIONS IN PROPANE. S.Goldhaber, G.Goldhaber, W.M.Powell and R.Silberbe
Phys. Rev. (USA), Vol. 121, No. 5, 1525-33 (March 1, 1961).

An experiment to study the $\bar{p}$ annihilation process at 1.05 BeV was performed with the Lawrence Radiation Laboratory 30 in. propane bubble chamber. It was observed that the K-meson production in annihilation events rises sharply with the increase in energy, namely from 4 ± 1% for annihilations at or near "rest" to 8 ± 1%. On the other hand, the pion multiplicity was not observed to increase appreciably with the increase of available energy. A pion multiplicity of 5.0 ± 0.2 was found. These numbers are discussed and compared with existing models for the $\bar{p}$ annihilation process. It is pointed out that with further increase in bombarding energy different models may differ appreciably in the above quantities. A $\bar{p}$–H annihilation cross-section of 51 ± 10 mb and a $\bar{p}$–C annihilation cross-section of 368 ± 60 mb were found at a p momentum of 1.05 BeV/c. Crude determinations of the $\bar{p}$ charge-exchange process — which turns out to be forward peaked — and of $\bar{p}$ inelastic-scattering events leading to pion production are also discussed.

# Neutrons

4798 THE NEUTRON SPECTRUM OF THE d + p REACTION
N.A.Vlasov, S.P.Kalinin, B.V.Rybakov and V.A.Sidorov
Zh. eksper teor. Fiz. (USSR), Vol. 38, No. 6, 1733-7 (June, 1960). In Russian.

The neutron spectra of the reactions H(d, n)2p (with $E_d$ = 18.6 MeV) and D(p, n)2p (with $E_p$ = 8.6 MeV) were measured at an angle of 0° by the time-of-flight technique. The forms of the spectra can be satisfactorily explained by pair interaction between nucleons in the final state. [English translation in: Soviet Physics – JETP (USA), Vol. 11, No. 6, 1251-3 (Dec., 1960)].

799 INFLUENCE OF ERGODIC BEHAVIOR ON THE SCATTERING OF SLOW NEUTRONS BY A HARMONIC LLATOR. T.J.Krieger.
. Rev. (USA), Vol. 121, No. 5, 1388-90 (March 1, 1961).
Random quantum jumps of a harmonic oscillator in contact with perature bath are shown to give rise to a general broadening e slow-neutron scattering peaks. An exception occurs in the of the elastic scattering peak, a major component of which re- s unbroadened. In general, the broadening increases with the ber of quanta transferred. The analysis is based on the "damped" lator model of Senitzky (Abstr. 14519 of 1960).

4800 NEUTRON–NEUTRON SCATTERING LENGTH. K.W.McVoy.
. Rev. (USA), Vol. 121, No. 5, 1401-10 (March 1, 1961).
The final-state interaction of the two neutrons from the re- n $\pi^- + d \rightarrow 2n + \gamma$ has a pronounced and distinctive effect on the entum spectrum of the outgoing particles. In particular, the on spectrum is sharply peaked in the neighbourhood of 2 MeV, a shape that is quite sensitive to the strength of the nn inter- n. In the region of this peak, the relative neutron–neutron entum is so small that the nn interaction is completely character- by its scattering length. Hence it is proposed that a measure- of the shape of the neutron spectrum from this reaction may ide a convenient means of measuring the neutron–neutron ering length. Neutron spectra are calculated in an impulse oximation, for several assumed values of the scattering length pears from their shapes that, in this way, present neutron- ction techniques should be capable of determining the scattering h to within 25%.

RADIATIVE TRANSFER THEORY OF NEUTRON DIFFUSION. Abstr. 4289

4801 A MECHANICAL VELOCITY SELECTOR FOR SUB-THERMAL NEUTRONS AND ITS USE IN THE MEASURE- NT OF THE TOTAL EFFECTIVE CROSS-SECTION OF DMIUM, SAMARIUM, EUROPIUM AND GADOLINIUM. P.Höhne.
Phys. (Germany), Vol. 7, No. 1-2, 50-65 (1961). In German.
The selector is a rotating plastic cylinder containing cadmium 80 helical slots milled in its surface down which the neutrons s. It selects energies between 0.15 and $3 \times 10^{-3}$ eV. The cali- ion and the determination of the transmission function (half- h 0.3 $\lambda_0$, transmission 57%) and the neutron spectrum of the ctor is described. The total cross-sections of Cd, Sm, Eu and nd their resonance parameters were measured using the ctor and compared with theoretical values. D.H.Lord

4802 SCINTILLATION SPECTROMETER FOR FAST NEUTRONS. Yu.A.Egorov.
bory i Tekh. Eksper. (USSR), 1958, No. 3, 21-6 (May-June).
tussian.
Two scintillation spectrometers were constructed. The spec- n of a Po + Be source was measured using the spectrometer a scattering angle of 45°. The block diagram of the other ctrometer with a scattering angle of 70° and the method of king up the results of measurements with this spectrometer are sidered. The calibrations were made with the help of measure- nts on the $\alpha$-spectrum of $Po^{210}$ and the $\beta$-spectra of $Cs^{134}$ and . In order to test the second spectrometer, the absorption of neutrons in concrete, water and paraffin were measured. asurements were carried out on a heavy-water nuclear reactor. eriment showed that the spectrometer works reliably even in ditions of high $\gamma$-background and can be used for the measure- nt of various neutron sources. [English translation in: Instrum. er. Tech. (USA), No. 3, 341-5 (May-June, 1958; publ. July, 1959)].

THE MEASUREMENT OF LOW-LEVEL NEUTRON FLUX ANSIENTS. See Abstr. 4545

PULSED NEUTRON SYSTEM FOR REACTOR MEASUREMENTS. Abstr. 4885

4803 ENERGY OF A LOW DENSITY NEUTRON GAS. P.C.Sood and S.A.Moszkowski.
clear Phys. (Internat), Vol. 21, No. 4, 582-94 (Dec. (3), 1960).
The energy of a neutron gas is calculated in the low-density it using the singlet S state shift corresponding to the Gammel– aler potential. The corrections to this energy are evaluated uming a factorable interaction (i.e. a separable potential). The rection due to the Pauli exclusion principle and the pairing correction, i.e., depression of the ground-state energy due to pair correlations (similar to that in the theory of superconductivity) are calculated. It is concluded that a pure neutron gas is unbound even at very low densities.

# Mesons

4804 SEARCH FOR THE $\rho^0$-MESON AND A CHECK OF THE DISPERSION RELATIONS IN $\pi$N-SCATTERING. V.G.Zinov, A.D.Konin, S.M.Korenchenko and B.Pontekorvo [Pontecorvo].
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1708-14 (June, 1960). In Russian.
The total $\pi^-\rho$-interaction cross-sections ($\sigma_t$) were measured with an accuracy of 1.5-2% for about 50 pion energies lying between 140 and 360 MeV. The pion energy was known to within ±1%. No anomalies in the energy dependence of $\sigma_t$ were found which could indicate the existence of a $\rho^0$-meson with a mass in the interval of 270-410 MeV. The data are inconsistent with the energy values $E_2 = 650$ MeV for the second maximum in $\sigma_t$ found by Frisch et al. (Abstr. 6027 of 1959) but agree with the conclusion of Brisson et al. (Abstr. 3989 of 1960) that it should be located at a smaller energy ($E_2 \cong 610$ MeV). The data are in agreement with the dispersion relations for $\pi^-\rho$-scattering. It is thus demonstrated that the Puppi–Stanghellini problem as such no longer exists and that it arose only as a result of inaccurate knowledge of the total $\pi^-\rho$-interaction cross-section. [English translation in: Soviet Physics – JETP (USA), Vol. 11, No. 6, 1233-8 (Dec., 1960)].

MUON LIFETIME, CALCULATION FROM $O^{14}$ DECAY ENERGY. See Abstr. 4847

4805 SOLUTION OF EQUATIONS FOR THE MESON–MESON SCATTERING AMPLITUDE IN THE ASYMPTOTIC REGION. A.A.Ansel'm.
Zh. eksper teor Fiz. (USSR), Vol. 38, No. 6, 1887-90 (June, 1960). In Russian.
The set of integral equations for the meson–meson scattering amplitude deduced by Dyatlov et. al (Abstr. 5214 of 1957) and Pomeranchuk et al. (Abstr. 7126 of 1956) is solved exactly. An integral equation for the amplitude which depends only on one variable is obtained as a direct mathematical corollary of this set [English translation in: Soviet Physics–JEPT (USA), Vol. 11, No. 6, 1356-8 (Dec., 1960)].

4806 ANOMALOUS CREATION OF $\mu$-MESONS ORIGINATING IN WEAK INTERACTIONS. H.Nagai and D.Itô.
Progr. theor. Phys. (Japan), Vol. 23, No. 6, 1207-9 (June, 1960).
A first-order calculation, on the collision between a proton and a fixed force field, suggests that cross-sections for $\mu$-production via weak interactions and $\pi$-production via strong interactions become comparable when the transferred energy is of order $10^{15}$ eV. Such $\mu$-mesons would be sharply collimated. It is suggested that there is an experimental anomaly at this energy. J.E.Paton

NUCLEAR TRACK EMULSIONS FOR THE STUDY OF Π-MESONS. See Abstr. 4751

4807 TWO PION EXCHANGE INTERACTION. G.Breit, K.E.Lassila, H.M.Ruppel and M.H.Hull, Jr.
Phys. Rev. Letters (USA). Vol. 6, No. 3, 138-41 (Feb. 1, 1961).
Phase shift analyses of pp and pn scattering are examined for evidence of two pion exchange effects. Both potential calculations and dispersion relations calculations of TPE effects are used in the comparison. Some positive evidence is found in the $^1D_2$, $^3D_2$ and $^3D_3$ waves. D.W.L.Sprung

4808 ON THE EDWARDS–MATTHEWS APPROACH TO $\pi$–N SCATTERING. Chan Hong-Mo.
Phil. Mag. (GB), Vol. 6, 201-8 (Feb., 1961).
In an attempt to extend the Edwards–Matthews (Abstr. 5066 of 1957) theory of $\pi$–N scattering to higher relativistic energy it was discovered that their evaluation of the fourth-order Feynman graphs was incorrect, involving an expansion which fails to converge at the threshold of physical scattering energy. A new evaluation of these graphs is then carried through and the result substituted into their scattering formula. The new values do not show the agreement with experiment found in Edwards and Matthews' original results. A study of the Feynman graphs and the method of their evaluation are briefly described.

4809 TWO-PION EXCHANGE MECHANISM IN $K^+N$ SCATTERING. B.W.Lee.
Phys. Rev. (USA), Vol. 121, No. 5, 1550-2 (March 1, 1961).

The exchange of two pions resonating in the T = 1, J = 1 state between the $K^+$-meson and nucleon in $K^+N$ scattering is considered in the double dispersion representation to account for the energy dependence of the $J = \frac{1}{2}$ amplitudes. The result here is in qualitative agreement with that of Ferrari et al. (Abstr. 15437 of 1960), obtained for $K^-N$ scattering.

# Hyperons

4810 SPIN AND PARITY ANALYSIS FROM PRODUCTION AND DECAY OF HYPERON RESONANT STATES. R.Gatto and H.P.Stapp.
Phys. Rev. (USA), Vol. 121, No. 5, 1553-5 (March 1, 1961).

Processes dominated by the $\Lambda-\pi$ resonance state, Y*, should exhibit correlations permitting the determination of the Y* spin; the relative parities of the $\Lambda$, $\Sigma$, K, and Y*; and the ratios of the various hyperon decay asymmetry parameters. The cases of Y* spin $\frac{1}{2}$ and $\frac{3}{2}$ are examined in detail and a number of exact relations between measurable quantities are given for the various spin and parity assignments. The longitudinal component of polarization of the hyperon from the Y* decay is, for parity-conserving reactions, the same for all final hyperons, independent of their parities. This allows the ratio of the decay asymmetry parameters for various hyperons to be determined. For a given Y* spin the transverse hyperon polarization is determined by the longitudinal polarization up to a sign which is fixed by the Y*–hyperon parity. Thus the transverse polarizations for final $\Lambda$ and $\Sigma$ particles will be the same or opposite if the parities are the same or opposite, respectively. For the spin $\frac{3}{2}$ case, there are four independent contributions to the longitudinal polarization, each proportional to a different pseudoscalar spherical harmonic of the decay direction. These give four independent experimental determinations of the ratios of the decay asymmetry parameters. Similarly, from the transverse components there are six independent determinations of relative parities. If the initial and final states of the production process are restricted to S and P waves, all ten of the experimental parameters determining the hyperon polarization are given, except for the aforementioned sign dependence on the Y*–Y relative parity, by a single parameter in a manner fixed by the K–Y* parity.

4811 CROSS SECTION AND DECAY ASYMMETRIES OF NEUTRAL V PARTICLES PRODUCED IN COPPER BY $\pi^-$ MESONS. G.R.Kalbfleisch.
Phys. Rev. (USA), Vol. 121, No. 5, 1544-9 (March 1, 1961).

The charged mode of decay of 189 A and 77 $K^0$ particles produced by 1.12 BeV/c $\pi^-$-mesons in the copper wall of the Berkeley 10 in. liquid hydrogen bubble chamber were analysed and their asymmetries calculated. The asymmetries were examined for several interesting subgroups of the sample and for several directions of quantization. A fore–aft asymmetry in $\Lambda$-decay has previously been reported in cosmic-ray interactions with complex nuclei and in some machine events of a similar nature. This asymmetry has recently been reviewed and summarized by Salmeron and Zichichi (Abstr. 9997 of 1959). They find a 3-standard-deviation effect, $\langle \alpha P_{\text{fore-aft}} \rangle_{\text{av}} = -0.56 \pm 0.15$. In contrast, the asymmetries found here for both $\Lambda$ and $K^0$ are consistent with the assumption of conservation of parity in the production process $\pi^- + p$ (in nucleus) $\rightarrow \Lambda + K^0$. The cross-section for the associated production of $\Lambda K^0$ and $\Sigma^0 K^0$ is determined as 10.5 ± 0.9 mb per copper nucleus. This value is somewhat larger than that expected on the assumption that the nucleons interact in first approximation as free nucleons possessing Fermi momentum according to an $A^{2/3}$ scaling of the hydrogen cross-sections. This scaling predicts a value for this cross-section of 7.4 ± 0.8 mb/nucleus. Subsequent interactions of the hyperons with another nucleon in the same nucleus in which they were produced are frequent. A lower limit for the probability of scattering of the $\Lambda$ can be set at 0.23 ± 0.07. This is in accordance with the observed $\Lambda$ + p cross-sections.

4812 INVESTIGATION INTO THE ELASTIC SCATTERING OF $\Sigma^\pm$ HYPERONS ON HYDROGEN. F.R.Stannard.
Phys. Rev. (USA), Vol. 121, No. 5, 1513-22 (March 1, 1961).

The experiment was based on a sample of 12 000 $\Sigma^-$-particles formed in a propane bubble chamber by the interactions of 1.5 BeV/c $K^-$ mesons. A total track length of 210 metres in the energy range 100 to 700 MeV was examined. Ten examples were found of the reaction $\Sigma^+ + p \rightarrow \Sigma^+ + p$, and six of the reaction $\Sigma^- + p \rightarrow \Sigma^- + p$. The estimates of the cross-sections for the two processes are, respectively, $38_{-14}^{+18}$ mb and $10_{-4}^{+6}$ mb. The scattering angle distributions in the c.m. system appear isotropic for the $\Sigma^+$ particles, and peaked forward for the $\Sigma^-$ particles. The results are discussed in relation to various theoretical predictions, and, in particular, some evidence is found favouring the Gammel–Thaler method of treating the triplet odd-parity nucleon–nucleon potential.

# COSMIC RAYS

*(Nuclear reactions due to cosmic rays are included under Nuclear Reactions)*

4813 COSMIC RADIATION PROBLEMS IN ASTRONAUTICS. K.Sitte.
Bull. Res. Coun. Israel, Vol. 8C, No. 1, 7-16 (Feb.; 1960).

4814 A PHENOMENOLOGICAL MODEL FOR HIGH-ENERGY INTERACTIONS. I. MULTIPLICITIES AND CROSS-SECTIONS. K.Sitte.
Bull. Res. Coun. Israel, Vol. 9F, No. 3, 93-110 (Dec., 1960).

In an attempt to investigate the possibility of deriving the relevant features of nucleon–nucleon interactions at high energies from a purely phenomenological model, the inelasticities, cross-sections and average multiplicities were calculated for a number of cases. It is shown that models of overlapping fields, first introduced by Heisenberg, lead to excessively large values of the cross-sections which are incompatible with experimental data. If, instead, the overlap volume of nucleons of tapered shape — approximated by a Gaussian with a = 2 outside of a constant-density region of radius $r_0 = 0.75 \times 10^{-13}$ cm — is taken as a measure of the energy transfer, reasonable values for the cross-sections are obtained. K-meson production of the right abundance can also be predicted by assigning it to a "core" of radius $\sim\frac{1}{2} r_0$. But the average multiplicity increases too rapidly with the primary energy if the customary postulation of complete inelasticity for head-on collisions is maintained. This can be eliminated by assuming that the maximum possible energy transfer depends on the collision time. Tentatively ascribing $k_\gamma \cong 0.5$ to interactions at $\gamma = 10^5$, satisfactory results for both cross-sections and multiplicities were obtained. Some consequences of the model for the energy spectrum of jets, the multiplicity distribution, and the characteristics of collisions at air shower energies are discussed. In the air shower region, the model permits at least in a qualitative way, the interpretation of the anomalous diurnal variations observed by McCusker (Abstr. 4763 of 1959, 2152 of 1961), and of the occurrence of collimated groups of $\mu$-mesons apparently created in the highest parts of the atmosphere. But in its present form it is probably still inadequate to describe precisely the longitudinal development of air showers near their origin.

4815 MEASUREMENTS OF RADIATION DURING THE FLIGHT OF THE THIRD COSMIC ROCKET. S.N.Vernov, A.E.Chudakov, P.V.Vakulov, E.V.Gorchakov, Yu.I.Logachev and A.G.Nikolaev.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 2, 322-4 (Jan. 11, 1961). In Russian.

The third cosmic rocket which started into space on 4th Oct 1959 carried apparatus for recording rapidly moving charged particles and photons. This consisted of one scintillation counter and three gas-discharge counters. Signals were transmitted to earth once every 24 hours, over a period of one hour. The integrated intensity of radiation received by the apparatus in the intervals between the one-hour transmissions was also measured and the value transmitted to earth. The paper gives preliminary results derived from signals received on earth between 4th October and 18th October 1959. The intensity of cosmic rays, undistorted by earth's atmosphere and magnetic field, is derived from signals from the rocket when in interplanetary space. A table gives comparable results from all the three cosmic rockets. Graphs showing (a) the diurnal intensities received from the third rocket and (b) two-hour intensities from a terrestrial neutron monitor, recording the same radiations, plotted against time and covering the same period, reveal the changes caused by the earth's atmosphere and magnetic field. The effect of solar eruptions is discussed. [English translation in Soviet Physics–Doklady (USA)]. N.D.

816 POSSIBLE INTERCONNECTION BETWEEN NUCLEON-STRUCTURE AND MULTIPLE PRODUCTION IN IC RAY ENERGY REGIONS. H.Nagai and D.Itô.
r. theor. Phys. (Japan), Vol. 23, No. 5, 966-7 (May, 1960).
The spatial extension of the "fireballs" postulated in the "two-e" model of multiple production proposed by Niu and others r. 5090 of 1958; 3738, 3754 of 1959) is estimated by analysing istribution of transverse momenta of secondary particles. ement is obtained with experimental distributions and the s. radius of a "fireball" is found to be $0.92 \times 10^{-13}$ cm.
J.L.Redding

1817 ENERGY LOSSES OF FAST $\mu$-MESONS IN THICK LAYERS OF MATTER. M.I.Daion.
eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1668-72 (June, 1960).
ssian.
An allowance for energy losses of $\mu$-mesons in the earth's t showed that the $\mu$-meson spectrum measured underground m water equivalent) agrees with the results of measurements a level. [English translation in: Soviet Physics—JETP (USA), 11, No. 6, 1203-6 (Dec., 1960)].

# NUCLEUS

4818 MATTER AT HIGH DENSITIES.
E.E.Salpeter.
Phys. (USA), Vol. 11, No. 4, 393-413 (Dec., 1960).
The equation of state of matter in its most stable form at dif-nt densities $\rho$ and at zero temperature is discussed. Using tive range theory and the low density limit of the nuclear many- formalism, the energy and pressure of a neutron gas is cal-ted at densities where the interparticle distance is large com-d with the effective range. Energy and pressure of a neutron at densities comparable to nuclear densities are estimated next, g a semiempirical method. Most probably neutron matter is ound at any density. Coulomb effects and the effect of beta-ys are considered and it is found that free neutrons are at librium with ionized nuclei like $Tc^{145}$ at a density of about $10^{11}$ g/cm$^3$ with an electron Fermi energy of about 23 MeV. the unlike case of bound neutron matter an "electron skin" ounding large neutron drops contributes a negative surface ion and neutron drops of radius about 100 fermis would pro-y be most stable. At densities above $10^{15}$ g/cm$^3$ hyperons ist with protons and neutrons and their effect on the pressure nsidered. At very high densities, a simple approximation is n for the pressure due to the proximity of the hard repulsive s of nuclear forces.

4819 EFFECTIVE SPIN–ORBIT POTENTIAL IN CORRELATED HEAVY NUCLEI. J.W.Clark.
. Phys. (USA), Vol. 11, No. 4, 483-500 (Dec., 1960).
A many-body system is considered in which a particle N es under the influence of the remaining N−1 particles, taken to ucleons, and every total particle-particle interaction contains a ulsive core. An expression is derived for that part of the effect-one-body potential felt by particle N which is due to a specific ion $v_{iN}$ of its interaction with each of the nucleons i = 1, ..., ., on the basis of a system wave-function of the Jastrow type, ecting exchange contributions involving particle N. This result sed to estimate the spin–orbit splittings in the region of $Pb^{208}$ rated by the Gammel–Thaler and Signell–Zinn–Marshak two-spin–orbit potentials. In both cases the theoretical splittings of the correct sign and about the right magnitude to explain the rved doublet separations.

4820 ON THE EFFECTIVE INTERACTION IN FINITE NUCLEI. B.Bremond.
ear Phys. (Internat.), Vol. 22, No. 3, 434-8 (Feb., 1961).
The expectation values of the two nucleons interaction are ulated using Brueckner's matrix and shell-model wave-functions. e values are compared with phenomenological ones. The dis-ancies can be explained by the effected approximations.

1821 MOTION OF NUCLEONS IN AN ANISOTROPIC OSCILLATOR POTENTIAL WITH AN ALLOWANCE FOR -ORBIT INTERACTION. D.V.Volkov and E.V.Inopin.
eksper. teor. Fiz. (USSR), Vol. 38, No. 6. 1765-70 (June, 1960).
ssian.
A method is proposed for calculation of the wave-functions and energy levels of nucleons moving in an oscillator potential. The general case of a potential which does not possess axial symmetry but which accounts for spin–orbit interaction is considered. An essential feature of the calculations is that use is made of smallness of the spin–orbit coupling constant. In the limiting case of a strongly deformed nucleus the solution can be obtained in a simple analytical form. Investigation of this solution indicates that the spin–orbit interaction significantly affects the axial symmetry of the nucleus. Thus the axially symmetric shape of the nucleus becomes more stable and is the cause of the discontinuous nature of the transition from axial nuclei to non-axial ones. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1273-6 (Dec., 1960)].

4822 ON THE STABILITY OF A SOLUTION OF A PHENOMENOLOGICAL OPTICAL MODEL. G.Domokos.
Acta phys. Hungar., Vol. 12, No. 2, 179-80 (1960).
Discusses the determination of an absorptive potential from a cross-section, in a semi-classical approximation.
R.J.N Phillips

4823 SUPERFLUID MODEL OF THE NUCLEUS.
V.G.Solov'ev.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 325-8 (July 11, 1960). In Russian.
For abstract, see Abstr. 17467 of 1960. [English translation in: Soviet Physics–Doklady (USA), Vol. 5, No. 4, 778-81 (Jan.-Feb., 1961)].

4824 ALPHA–DEUTERON MODEL OF THE $Li^6$ NUCLEUS.
T.I.Kopaleishvili, I.Sh.Vashakidze, V.I.Mamasakhlisov and G.A.Chilashvili.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1758-64 (June, 1960). In Russian.
Assuming that nucleons of the $Li^6$ nucleus form predominantly $\alpha$-particle and deuteron subsystems, the energy of relative motion of these subsystems is calculated and it is shown that the energy has a minimum in the negative value region. The energy of the $0^+$, T = 1 excited state of the $Li^6$ nucleus is also determined. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1268-72 (Dec., 1960)].

4825 SOME POSSIBILITIES OF EXPERIMENTAL VERIFICATION OF THE MODEL OF NON-AXIAL NUCLEI WITH A ROTATIONAL SPECTRUM. D.P.Grechukhin.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1891-3 (June, 1960). In Russian.
It is shown that observation of E0-transitions of the $I^+ \rightarrow I^+$ type (I is the nuclear spin) in even-even nuclei is a crucial test of the model of non-axial nuclei with a rotational spectrum. The isotopic shift predicted by the model is considered. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1359-60 (Dec., 1960)].

SHELL-MODEL CALCULATIONS FOR MASS 12 NUCLEI, PERTINENT TO A TEST OF THE CONSERVED VECTOR CURRENT THEORY. See Abstr. 4844

SPIN OF EXCITED LEVELS OF $Rh^{103}$. See Abstr. 4851

4826 MAGNETIC MOMENT AND HYPERFINE STRUCTURE COUPLING OF THE FIRST 2+ STATE IN $Gd^{154}$.
R.Stiening and M.Deutsch.
Phys. Rev. (USA), Vol. 121, No. 5, 1484-92 (March 1, 1961).
The g value of the 0.123 MeV 2 + state of $Gd^{154}$ is found to be g = 0.36 ± 0.06. The hyperfine structure constant of the same nuclear state in the $^8S_{7/2}$ ground state of $Gd^{3+}$ in aqueous solution is determined as a = 26.4 ± 5 Mc/s. The perturbation of the angular correlation of gamma-ray cascades proceeding through this state was studied. It is found that the perturbation in aqueous solution can be decoupled by magnetic fields either parallel to one of the gamma rays or perpendicular to the plane of observation. The perturbation in molten $GdCl_3$ is found to be much weaker than in solution and to be unaffected by magnetic fields. Auxiliary measurements involving the first 2+ states in $Sm^{152}$ and $Gd^{156}$ are described.

ELECTRIC QUADRUPOLE MOMENT OF Eu. See Abstr. 4903

DEFORMATION OF THE $Th^{229}$ NUCLEUS: DERIVATION FROM ATOMIC SPECTRUM ISOTOPE SHIFT. See Abstr. 4906

4827 METHODS OF NUCLEAR ORIENTATION.
E.Ambler.
Progress in cryogenics. Vol. 2 (see Abstr. 4509 of 1961) p. 233-80.

Review intended primarily to illustrate the potentialities of the technique in nuclear physics. The methods of orientating nuclei and experiments performed with oriented nuclei are classified. Static, dynamic and transient methods are considered, and a notation is defined. The applications to nuclear physics discussed include $\alpha$-decay, $\beta$-decay and $\gamma$-emission. 152 refs. J.B.Birks

INFLUENCE OF MAGNETIC INTERACTION ON NUCLEAR ORIENTATION OF COBALT-60 IN RARE-EARTH DOUBLE NITRATES. See Abstr. 3586

NUCLEAR ORIENTATION AND OVERHAUSER EFFECT. See Abstr. 3944

THE MÖSSBAUER EFFECT IN TIN FROM 120°K TO THE MELTING POINT. See Abstr. 3604

4828 HYPERNUCLEI PRODUCED BY K⁻INTERACTIONS IN NUCLEAR EMULSIONS. I. MESIC DECAYS.
M.M.Nikolić.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 595-8 (Dec. (3), 1960).

Eleven hypernuclei decaying according to the $\pi^-$ mesic mode were found in examining 415 K⁻ interactions in flight and 1104 K⁻ absorptions at rest. Nine of these hypernuclei were uniquely identified while for the remaining two there are several possible interpretations.

4829 HYPERNUCLEI PRODUCED BY K⁻INTERACTIONS IN NUCLEAR EMULSIONS. II. GENERAL CHARACTERISTICS AND NON-MESIC DECAYS.
V.Gorgé, W.Koch, W.Lindt, M.Nikolić, S.Subotić-Nikolić and H.Winzeler.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 599-623 (Dec. (3), 1960).

Sixty possible hypernuclei produced in 1104 K⁻interactions at rest and 415 K⁻interactions in flight, were analysed. The hypernucleus charge distribution was determined and the non-mesic to $\pi$-mesic ratio was given as a function of the hyperfragment charge. The stimulated decay was discussed. The hypernucleus formation probability was estimated.

# Energy Levels

4830 RELATION BETWEEN MANY-BODY AND SINGLE-PARTICLE ASPECTS IN NUCLEI.
G.E.Brown and D.J.Thouless.
Suppl. to Physica (Netherlands), Vol. 26, S145-S154 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). Simple excitations described by the creation of a particle and a hole in the shell model are coupled together by the interaction to give collective states. The giant dipole resonance and the oscillations of closed-shell nuclei are used to illustrate this mechanism, and the theory is compared with the theory of plasma oscillations. A schematic model is introduced that demonstrates the separation of the dipole level from the shell-model levels. An attractive interaction leads to the raising of collective states of isotopic spin unity and to the lowering of states of isotopic spin zero. The importance of ground-state correlations is emphasized, and their effects are discussed. Results of calculations for the dipole and octupole states of $O^{16}$ and $Ca^{40}$ using a zero-range potential are quoted and compared with more accurate work on $O^{16}$. D.J.Thouless

4831 INTERPRETATION OF THE LEVEL SCHEME OF CADMIUM 112. C.Ythier.
C.R. Acad. Sci. (France), Vol. 251, No. 25, 2915-17 (Dec. 19, 1960). In French.

It is suggested that the level scheme can be decomposed into four sets of vibrational levels each based on a $0^+$ state. The level scheme constructed in this way is compared with experimentally observed data. L.L.Green

4832 LEVELS IN $Th^{228}$ EXCITED IN THE ELECTRON CAPTURE DECAY OF $Pa^{228}$.
E.Arbman, S.Bjørnholm and O.B.Nielsen.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 406-37 (Dec. (1), 1960).

22 hr $Pa^{228}$ was produced by (p,5n) reactions on $Th^{232}$. The decay was studied by means of a double-focusing high-resolution $\beta$-spectrometer, a six-gap high-transmission $\beta$-spectrometer, scintillation spectrometers, and coincidence techniques. More than 200 conversion lines were found. Of these, 153 were ascribed to the $Pa^{228}$ decay on the basis of their half-lives and assigned to 72 $\gamma$-transitions in $Th^{228}$. Numerous coincidence relations between conversion lines and $\gamma$-rays were measured. A decay scheme comprising 22 excited states, ranging from 57.5 keV to 1943 keV, is presented and discussed with respect to the quantum numbers $(K, I, \pi)$. In addition to the ground-state rotational band, the level structure indicates the presence of three or four rotational bands, built on intrinsically excited states. The possible collective vibrational character of the lower lying intrinsic states is discussed. Theoretical branching ratios and selection rules associated with the quantum number K are compared with experiment and discussed.

DISPERSION FORMULAE FOR OVERLAPPING LEVELS. See Abstr. 4859

4833 COULOMB EXCITATION WITH 14-20 MeV $\alpha$-PARTICLES: DOUBLE EXCITATIONS AND SYSTEMATICS OF VIBRATIONAL STATES IN THE RARE EARTH REGION. O.Nathan and V.I.Popov.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 631-51 (Dec. (30, 1960).

Reports an exploratory investigation of nuclei in the rare-earth region by means of the Coulomb excitation process, using 14-20 MeV $\alpha$-particles as projectiles and studying the de-excitation $\gamma$-rays. Rotational double excitations were systematically observed in deformed even nuclei and evidence for double E2–E2 excitations was also found in some non-rotational, even nuclei. In single excitation several $\gamma$-rays were seen which were reported previously in Coulomb excitations, and approximate values for the corresponding partial reduced E2 transition probabilities $\epsilon B(E2)$ were determined. Tentative level schemes are proposed which will explain the observations, and the nature of the excited states is discussed on the basis of the measured $\epsilon B(E2)$ values. In particular it is pointed out that the reported results, together with other data, may indicate the presence of $\gamma$-vibrations in $Ho^{165}$ and some other deformed nuclei with odd number of protons.

4834 THE POSSIBILITY OF USE OF THE (n, 2n) REACTION IN NUCLEAR SPECTROSCOPY.
V.V.Komarov, A.B.Kurepin and A.M.Popova.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1824-8 (June, 1960). In Russian.

The (n, 2n) reaction is treated as a stripping reaction. The angular distribution of the centre of mass of two neutrons emitted simultaneously as a result of direct interaction is computed. The interaction between the emitted neutrons in the final state is found to be important. As an example, the angular distributions are calculated for the reactions $Be^9(n, 2n)Be^8$ and $Pb^{208}(n, 2n)Pb^{207}$, corresponding to the levels 2.9 MeV and 1.63 MeV of the final nuclei. It is shown that it should be possible to elucidate the mechanism of the reaction (n, 2n) and determine the characteristics of the nuclear energy levels by investigating the angular dependences in the spectra of neutrons emitted from targets irradiated with neutrons.
[English translation in: Soviet Physics–JETP (USA), Vol. 11, No. 6, 1312-15 (Dec., 1960)].

# NUCLEAR DECAY RADIOACTIVITY

4835 THE HIGH-FREQUENCY DEFLECTION METHOD FOR MEASURING SHORT HALF-LIVES. II. THE ELECTRON COINCIDENCE SPECTROMETER AND RELATED ARRANGEMENTS USED IN CONNECTION WITH THE HIGH FREQUENCY DEFLECTING TIME MEASURING INSTRUMENT. T.Alvager.
Ark. Fys. (Sweden), Vol. 17, Paper 29, 495-515 (1960).

For Pt I see Abstr. 17518 of 1960. The focusing arrangements used in the experimental set-up for investigation of the high frequency deflection method for measuring short half-lives (of the order of $10^{-10}$ sec or less) of isomeric states in nuclei are discussed. This includes a description of an electron–electron coincidence spectrometer. Further the time spread caused by the analysing magnets is considered. At present this time spread is about $10^{-10}$ sec, but can be decreases considerably, probably by a factor

10, by a special design of the high frequency deflection system. ne other arrangements, such as a special electrostatic system, ch will increase the coincidence counting rate by about an order magnitude and decrease the time spread, are also discussed.

4836 DETERMINATION OF THE HALF-LIVES OF RADIOACTIVE ISOTOPES WITH THE HELP OF A UBLE STATIC CALORIMETER. N.S.Shimanskaya. ibory i Tekh. Eksper. (USSR), 1958, No. 2, 95-7 (March-April). Russian.

The method and its evaluation from half-life measurements on $^{222}$ are described. [English translation in: Instrum. exper. Tech. SA), No. 2, 283-5 (March-April, 1958; publ. April, 1959)].

4837 A NEW DOSIMETRY METHOD FOR THE MEGARAD REGION. H.Wilski. omkernenergie (Germany), Vol. 4, No. 10, 402-3 (Oct., 1959). German.

The method, which can be used in the region 0.5-5.0 Mrad with accuracy of ±10%, is based on the changes in the plastic proper- s of polyethylene, above the crystallite melting point, after it is posed to ionizing radiations. The surface area increase of the lyethylene plate on melting is a measure of the radiation dose, e more intense the radiation the smaller the change in area. The riation of the area increase factor with dose is shown graphically 2 MeV electrons and for $Co^{60}$ $\gamma$-rays. I.C.Demetsopoullos

4838 THE DOSIMETRY OF $\beta$-RAYS IN RADIATION PROTECTION. K.Sommermeyer and H.Opitz. omkernenergie (Germany), Vol. 4, No. 10, 404-8 (Oct., 1959). In rman.

The measurement and calculation of dose of $\beta$-radioactive otopes is discussed experimentally and theoretically. A methane- led proportional counter was used for the measurements. With an ternal resistor of $10^{11}\Omega$ a dose rate of $10^{-9}$ rad/sec could be easured, the maximum permissible dose for finger and eye-lens posure being 1.5 and 0.3 rad/week respectively. Dose distribu- n functions are derived for point and thick sources and graphs are ven showing the directional dependence of dose and chamber sensi- ity, and the absorption of $\beta$-particles from thin and thick sources a function of Al thickness. I.C.Demetsopoullos

4839 THE FOUR RADIOACTIVE DECAY SERIES. H.Daniel. geb. exakt. Naturwiss. (Germany), Vol. 32, 118-79 (1959). German.

Review article.

4840 LIFETIME OF THE 161 keV EXCITED STATE IN $Sn^{117}$. F.R.Metzger. Franklin Inst. (USA), Vol. 270, No. 2, 138-42 (Aug., 1960).

Using the thermal resonance fluorescence method, the mean fe of the 161 keV M1 transition in $Sn^{117}$ was measured as $(.7^{+3.3}_{-1.6}) \times 10^{-10}$ sec. In arriving at this value, a total conversion efficient $\beta_T = 0.15$ was assumed.

4841 LIFETIMES OF EXCITED STATES OF NUCLEI WITH ODD MASS. R.E.Holland and F.J.Lynch. ys. Rev. (USA), Vol. 121, No. 5, 1464-71 (March 1, 1961).

The lifetimes of Coulomb-excited states in $Ti^{47}$, $Mn^{55}$, $Fe^{57}$, $Zn^{67}$, $e^{73}$, $Se^{77}$ and $Mo^{95}$ were measured by a pulsed-beam technique. ne observed mean lifetimes were between 0.1 and 12.7 m$\mu$sec. By mbining these data with the measured Coulomb-excitation cross- ctions, values are obtained for the partial mean life for magnetic- pole radiation and the ratio (E2/M1) for these transitions. The rtial M1 lifetimes are 20 to 200 times as long as the single- rticle estimates.

4842 NATURAL ALPHA RADIOACTIVITY IN MEDIUM-HEAVY ELEMENTS. R.D.Macfarlane and T.P.Kohman. hys. Rev. (USA), Vol. 121, No. 6, 1758-69 (March 15, 1961).

A large cylindrical ionization counter accommodating samples p to 1200 $cm^2$ in area was used for measurements of natural alpha adioactivity in medium-heavy elements. Low-background techniques nd multichannel pulse analysis were employed. The method has reater energy resolution and yields better counting statistics than ne nuclear emulsion technique, but does not have as great a sensi- vity. The results obtained from measurements on natural elements and isotopically enriched samples are:

| Nuclide | Alpha-particle energy (MeV) | Specific activity of natural element (dis $sec^{-1} g^{-1}$) | Half-life or limit for nuclide (year) |
|---|---|---|---|
| $Ce^{142}$ | ... | < 0.0002 | $> 5\times10^{16}$ |
| $Nd^{144}$ | 1.83 ± 0.03 | 0.0093 ± 0.0011 | $(2.4\pm0.3)\times10^{15}$ |
| $Sm^{146}$ | ... | < 0.013 | $< 3\times10^{8}$ |
| $Sm^{147}$ | 2.23 ± 0.02 | 116 ± 5 | $(1.15\pm0.05)\times10^{11}$ |
| $Sm^{148}$ | ... | < 0.04 | $> 2\times10^{14}$ |
| $Sm^{149}$ | ... | < 0.01 | $> 1\times10^{15}$ |
| $Gd^{152}$ | 2.14 ± 0.03 | 0.00156 ± 0.00010 | $(1.08\pm0.08)\times10^{14}$ |
| $Hf^{174}$ | 2.50 ± 0.03 | 0.000065 ± 0.000013 | $(2.0\pm0.4)\times10^{15}$ |
| $W^{180}$ | ... | < 0.00013 | $> 9\times10^{14}$ |
| $Pt^{190}$ | 3.11 ± 0.03 | 0.012 ± 0.001 | $(6.9\pm0.5)\times10^{11}$ |
| $Hg^{196}$ | ... | < 0.0007 | $> 1\times10^{14}$ |

4843 ANALYSIS OF LONG-RANGE ALPHA-EMISSION DATA. R.D.Griffioen and J.O.Rasmussen. Phys. Rev. (USA), Vol. 121, No. 6, 1774-8 (March 15, 1961).

Alpha barrier penetrabilities for the long-range alpha particles of $Po^{212}$ and $Po^{214}$ are calculated by using the diffuse exponential nuclear potential derived from optical-model analysis of alpha-particle elastic-scattering data. The calculations are made on the same basis as reported previously by Rasmussen (Abstr. 7322 of 1959, 1383 of 1960). Partial half-lives for alpha and gamma emission are calculated on the assumption that the long-range alpha decay is unhindered with respect to the ground-state alpha decay.

4844 SHELL MODEL CALCULATIONS FOR MASS 12 NUCLEI, PERTINENT TO A TEST OF THE CONSERVED VECTOR CURRENT THEORY. H.A.Weidenmüller. Nuclear Phys. (Internat.), Vol. 21, No. 3, 397-405 (Dec. (1), 1960).

Results of shell-model calculations are being reported, which determine whether two proposed experiments with mass 12 nuclei serve as good tests of the conserved vector current theory of $\beta$-decay. The measurement of the $\beta$-spectra in the decays of $B^{12}$ and $N^{12}$ to the ground state of $C^{12}$ seems to give a very good test of the conserved vector current theory. As a by-product, calculations are reported for various transition probabilities within the mass 12 nuclei: those involving the first excited state of $C^{12}$ are in poor agreement with experiment.

4845 EFFECT OF SUPERFLUIDITY OF HEAVY NUCLEI ON SINGLE-PARTICLE ELECTROMAGNETIC TRANSITIONS AND $\beta$-DECAY. M.G.Urin. Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1852-3 (June, 1960). In Russian.

Formulae are deduced for the probabilities of single-particle electromagnetic transitions and of $\beta$-decay, allowance being made for pair correlations of nucleons in heavy nuclei. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1331-2 (Dec., 1960)].

4846 THE CONNECTION BETWEEN THE $\beta$-ELECTRON POLARIZATION AND THE FORM OF THE $\beta$-SPECTRUM. B.V.Geshkenbein and A.P.Rudik. Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1894-5 (June, 1960). In Russian.

Established a correlation between the longitudinal polarization of $\beta$-electrons and the form of the $\beta$-spectrum. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1361-2 (Dec., 1960)].

4847 $O^{14}$ DECAY ENERGY AND THE FERMI INTERACTION CONSTANT. J.W.Butler and R.O.Bondelid. Phys. Rev. (USA), Vol. 121, No. 6, 1770-3 (March 15, 1961).

The threshold energy of the $C^{12}(He^3,n)O^{14}$ reaction was measured precisely with the use of a Van de Graaff accelerator and an electrostatic analyser, the value being 1436.2 ± 0.9 keV. From this value, the $O^{14}$ beta-decay end-point energy (for decay leading to the 2.312 MeV state in $N^{14}$) is computed to be 1.8000 ± 0.0065 MeV, based on the 1956 table of masses. A revised value of the Fermi interaction constant in beta decay is calculated and applied in the conserved vector current theory of Feynman and Gell-Mann. When (1) the radiative corrections and other corrections are applied to the decay of $O^{14}$; (2) the corrected ft value is used to compute the vector coupling constant in beta decay; (3) the value of this vector coupling constant is assumed to be the same as that for the muon decay and is used to

calculate the lifetime of the muon, and (4) this lifetime is corrected for radiation effects, the predicted mean life of the muon becomes 2.289 ± 0.013 μsec (based on the 1960 table of masses and the radiative corrections of Kinoshita and Sirlin) or 2.245 ± 0.013 μsec (based on the 1960 table of masses and the corrections, radiative and otherwise, of Durand and collaborators). The former value is 3.6% greater than a weighted average of several recent measurements of the muon mean life, 2.210 ± 0.002 μsec, while the latter value is only 1.6% greater, and is within the combined experimental and theoretical uncertainties. However, the definitions of coupling constants used by Durand and collaborators differ somewhat from those used by others.

LEVELS IN $Th^{228}$ EXCITED IN THE ELECTRON CAPTURE DECAY OF $Pa^{228}$. See Abstr. 4832

4848 GAMMA-RAY CORRELATION FUNCTION IN THE ADIABATIC APPROXIMATION. J.S.Blair and L.Wilets.
Phys. Rev. (USA), Vol. 121, No. 5, 1493-9 (March 1, 1961).

The gamma-ray correlation function following inelastic excitation of an even-A nucleus by a spinless projectile is analysed employing only the adiabatic approximation and theorems relevant to elastic scattering. The direction making equal angles with the incident and scattered directions in the scattering plane, the adiabatic recoil direction, is a convenient axis for quantization. In particular, the intermediate (excited) nucleus is populated with only even-M states, from which follows that the gamma distribution is unchanged by a rotation of $\pi$ about this axis. For a $0^+-2^+-0^+$ excitation de-excitation, the gamma distribution in the scattering plane reduces to the form $\sin^2[2(\theta_\gamma-\theta_0)]$, where $\theta_0$ is the adiabatic recoil axis. Comparison is made to the similar predictions of plane-wave Born approximation theories (in which the recoil direction for finite energy transfer is the symmetry axis) and to distorted-wave Born approximation calculations (for which, in general, there is no simple expression for the symmetry axis). Analysis of experiments verify the general features of the model, but further data obtained from forward scattering would be desirable to distinguish between the predictions of the adiabatic and Born approximations. Brief comments are made regarding gamma-ray polarization.

4849 DECAY OF $Hf^{180m}$.
W.F.Edwards and F.Boehm.
Phys. Rev. (USA), Vol. 121, No. 5, 1499-1503 (March 1, 1961).

The energies and relative intensities of the gamma radiation and the relative intensities of the conversion electrons following the decay of 5.5 hr $Hf^{180m}$ were measured using the curved-crystal gamma-ray spectrometer (recently calibrated for accurate intensity measurements), the ring-focused beta-ray spectrometer, and the semicircular spectrometer at the California Institute of Technology. The measured transition energies are: 57.54 ± 0.01, 93.33 ± 0.02, 215.25 ± 0.13, 332.5 ± 0.3, and 443.8 ± 0.6 keV. The energy levels deduced from these values are not entirely consistent with the two-parameter rotational formula. Conversion coefficients derived from the measurements were absolutely normalized using a method involving information available from the decay scheme. All of the 57.54 keV transition conversion coefficients are anomalously high if compared with the theoretical E1 coefficients. No admixture of M2 + E2 can account for the anomaly. The K-conversion coefficients of the E2 transitions are all about 10% low with exception of the 93.33 keV transition. The L-coefficients have a varying deviation, the maximum being 12%. The K-conversion coefficient of the 501.3 keV transition has the value 0.037 ± 0.012 which is consistent with the theoretical E3 value of 0.040.

4850 DECAY OF $Ne^{18}$.
J.W.Butler and K.L.Dunning.
Phys. Rev. (USA), Vol. 121, No. 6, 1782-7 (March 15, 1961).

$Ne^{18}$ was produced in the $O^{16}(He^3,n)Ne^{18}$ reaction by 5.2 MeV $He^3$ particles from a 5 MV Van de Graaff accelerator. The target, CaO on a Pt backing, was about 300 keV thick to the incident beam. The gamma rays following the decay of $Ne^{18}$ were detected by a 3 in. diameter by 3 in. NaI(Tl) crystal and a 256 channel pulse-height analyser. Only one nuclear gamma-ray was observed. Its energy, measured with respect to the $Na^{22}$ gamma ray at 1.2736 ± ± 0.0016 MeV, is 1.041 ± 0.005 MeV. Therefore, this gamma ray is assigned to the 1.04 MeV state of $F^{18}$. This state is considered to be the isobaric spin analogue state of the $Ne^{18}$ ground state, and therefore has quantum parameters $0^+$, T = 1. The branching to this excited state was measured to be 0.07 ± 0.02 (including a calculated contribution of 0.00006 from orbital electron capture), and that to the ground state of $F^{18}$ was measured to be 0.93 ± 0.02 (including a calculated contribution of 0.0002 from orbital electron capture). The ft values are, respectively, 3030 ± 880 and 1120 ± ± 70 sec. The half-life of $Ne^{18}$ was measured to be 1.46 ± 0.07 sec.

4851 GAMMA–GAMMA ANGULAR CORRELATIONS IN $Rh^{103}$.
B.P.Singh.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 450-5 (Dec. (1), 1960).

The angular correlations of gamma-rays in $Rh^{103}$ were studied for the 555 keV–55 keV and 440 keV–55 keV cascades. The correlation functions for the 555 keV–55 keV cascade was:

$$W(\theta) = 1 - (0.152 \pm 0.011)P_2(\cos\theta) - (0.042 \pm 0.017)P_4(\cos\theta),$$

and for the 440 keV–55 keV cascade:

$$W(\theta) = 1 + (0.049 \pm 0.013)P_2(\cos\theta) - (0.016 \pm 0.017)P_4(\cos\theta).$$

The spins of the excited levels at 650 keV, 535 keV and 95 keV of $Rh^{103}$ are discussed in the light of these correlation studies. The various possibilities of the spin values for these levels are summarized.

GAMMA-RAY ANISOTROPIES FROM ORIENTED $Pm^{144}$. See Abstr. 3587

# NUCLEAR REACTIONS

*(Including scattering by nuclei)*

4852 DISPERSION FORMULAE FOR OVERLAPPING LEVEL
V.I.Serdobolskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1903-6 (June, 1960).
In Russian.

Dispersion formulae are deduced in a theory in which the S-matrix is assumed to be linear with respect to resonances. The indefinite phase shifts of the complex reduced half-widths are calculated in a general form using the S-matrix unitarity condition. Cases are considered when an isolated level corresponding to compound nucleus formation in the optical resonance region or when two levels of a compound nucleus overlap or when a set of weakly overlapping levels exists in the optical resonance region. In all calculations it is assumed that levels of a compound nucleus do not overlap the nuclear reaction thresholds. [English translation in: Soviet Physics–JETP (USA), Vol. 11, No. 6, 1368-70 (Dec., 1960)]

4853 SELECTION RULES AND CORRELATIONS FOR POLARIZATION IN STRIPPING AND DIRECT PROCESSES. L.J.B.Goldfarb and R.C.Johnson.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 462-73 (Dec. (1), 1960).

Various selection rules for polarization and correlations between effects of incoming polarization and the polarization arising from unpolarized incoming beams are found for a variety of direct nuclear processes. Use is made of the distorted-wave Born approximation, with allowance made for spin-dependent distortion. The results are found without explicit evaluation of the parameters that are involved, but with attention given to the separate effects of the assumptions of parity conservation and the invariance of the interaction under time-reversal.

4854 METHOD TO OBTAIN THE ENERGY DEPENDENCE OF REACTION CROSS SECTIONS WHEN A COMPOUND NUCLEUS IS FORMED. R.Fox and R.D.Albert.
Phys. Rev. (USA), Vol. 121, No. 6, 1779-81 (March 15, 1961).

It is found that measuring the energy distributions of emitted particles at two different incident energies and two reaction cross-sections is sufficient to obtain the energy dependence of a reaction cross-section when it is known that a compound nucleus is formed. The cross-sections obtained are a function of the excitation energy of the residual nucleus. They are the usual reaction cross-section at zero excitation energy when the assumption is made that the reaction cross-section does not vary with the excitation energy of the target nucleus. By comparing the reaction cross-section thus obtained with measured nonelastic cross-sections, the compound elastic cross-section may also be obtained. An example using this

method is given in which two measured energy distributions and two measured cross-sections were used to obtain the energy dependence of the reaction cross-section of nickel in the 2.5 to 7 MeV energy range.

# Due to Photons

4855 RELATIVE ESCAPE AND ENERGY DISTRIBUTION OF PHOTO-DEUTERONS FROM COPPER.
A.P.Komar, E.D.Makhnovskii and V.P.Poddubnov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 797-9 (Aug. 1, 1960). In Russian.
For abstract, see Abstr. 17619 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 827-30 (Jan.-Feb., 1961)].

4856 INVESTIGATION OF HIGH-ENERGY PROTONS EMITTED IN THE PHOTODISINTEGRATION OF $Li^6$.
E.B.Bazhanov and L.A.Kul'chitskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1685-7 (June, 1960). In Russian.
Protons possessing energies of 16 MeV and above were studied. The excitation functions, angular distributions and np coincidences suggest that the probability of formation of highly excited states in the $He^5$ and $Li^5$ nuclei as a result of a single-particle reaction of the $Li^6$ nucleus should be quite high. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1215-17 (Dec., 1960)].

4857 SYSTEMATICS OF $(\gamma, 2n)$ REACTIONS.
I.C.Nascimento, G.Moscati and J.Goldemberg.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 484-91 (Feb., 1961).
The $(\gamma, n)$ and $(\gamma, 2n)$ cross-sections in $I^{127}$ and $Au^{197}$ were measured from threshold up to 22 MeV. A comparison is made between the experimental result and the evaporation theory. Other data available in the literature are included.

4858 RANGE OF 2 TO 60 keV RECOIL ATOMS IN Cu, Ag, AND Au.
W.A.J.van Lint, R.A.Schmitt and C.S.Suffredini.
Phys. Rev. (USA), Vol. 121, No. 5, 1457-63 (March 1, 1961).
The ranges of atoms recoiling from photoneutron reactions in Cu, Ag, and Au were measured utilizing foil-sandwich irradiations followed by standard radiochemical detection techniques. Different energy spectra of recoil atoms were achieved by varying the bremsstrahlung energy and the angle of emission relative to the incident photons. The results are compared with calculations of Holmes and Leibfried. The best fit to the data is achieved by assigning values of the multiplicative parameter of the screening radius, $\alpha$, equal to 1.7 for Cu, 2.0 for Ag, and 3.0 for Au.

# Due to Electrons

4859 COULOMB SCATTERING OF POLARIZED ELECTRONS.
W.R.Johnson, T.A.Weber and C.J.Mullin.
Phys. Rev. (USA), Vol. 121, No. 4, 933-9 (Feb. 15, 1961).
An approximate analytical expression for the spin-dependent cross-section for Coulomb scattering, valid to order $(\alpha Z)^4$, is developed. The development is based on a modification of the Sommerfeld—Maue wave-function. The $(\alpha Z)^2$ and $(\alpha Z)^3$ terms in the resulting cross-section are identical with the corresponding terms found by the second Born approximation. The $(\alpha Z)^4$ term is verified by analytically summing the corresponding term in the Mott series. Graphs, comparing the approximate analytical expressions for both the cross-section and asymmetry function with exact numerical results, are included.

4860 POLARIZATION OF ELECTRONS IN ELASTIC SCATTERING WITH AN ALLOWANCE FOR THE FINITE SIZE OF THE NUCLEUS. B.K.Kerimov and V.M.Arutyunyan.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1798-1802 (June, 1960). In Russian.
The scattering phase shifts and polarization of elastically scattered electrons are computed with allowance for the finite size of the scattering centre. An expression for azimuthal asymmetry in double scattering is derived as well as a correction to the usual Mott formula due to the second and fourth nuclear charge density moments. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1294-7 (Dec., 1960)].

# Due to Nucleons

4861 ON THE POLARIZATION OF HIGH ENERGY NUCLEONS ELASTICALLY SCATTERED FROM LIGHT NUCLEI.
Y.Sakamoto.
Progr. theor. Phys. (Japan), Vol. 23, No. 2, 382-5 (Feb., 1960).
Uses phase shifts from a certain "pion-theoretical" two-nucleon potential (Abstr. 20072, 20126 of 1960) to calculate an optical model and hence the polarization in scattering from light nuclei. Qualitative agreement is found with experiment. R.J.N.Phillips

4862 POLARIZATION OF NUCLEONS SCATTERED ON NON-ZERO SPIN NUCLEI. Yu.P.Elagin.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1870-1 (June, 1960). In Russian.
The optical model is employed in an analysis of the polarization of nucleons scattered on nuclei possessing spins differing from zero. It is shown that, generally speaking, such nuclei yield additional polarization compared with nuclei possessing the same optical parameters but no spin. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1344-5 (Dec., 1960)].

# Due to Protons

4863 SPIN DEPENDENCE OF HIGH ENERGY PROTON SCATTERING. T.T.Thwaites.
Ann. Phys. (USA), Vol. 12, No. 1, 56-67 (Jan., 1961).
The elastic scattering of 200 MeV polarized protons by $N^{14}$ was measured in the forward maximum of the cross-section and compared with the scattering produced by $C^{12}$ under the same conditions. No conclusive evidence for a nuclear spin dependence of the scattering was found.

4864 ON THE INELASTICALLY SCATTERED PROTON AT HIGH ENERGY. Y.Sakamoto.
Progr. theor. Phys. (Japan), Vol. 23, No. 6, 1205-7 (June, 1960).
A calculation is made of proton inelastic scattering from magnetic dipole levels, using the impulse approximation with Gammel–Thaler 180 MeV phase shifts, and replacing the radiative matrix element by the experimental radiation width. Good agreement with experiment is recorded for the angular distribution and polarization of protons inelastically scattered from the 15.11 MeV level of $C^{12}$. J.E.Paton

4865 ELASTIC SCATTERING AND RADIATIVE CAPTURE OF PROTONS BY $C^{13}$. D.F.Hebbard and J.L.Vogl.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 652-75 (Dec. (3), 1960).
Measurements of the elastic scattering of protons by $C^{13}$ from 140 keV to 750 keV proton energy are reported. The radiative capture of protons by $C^{13}$ was investigated down to a proton energy of 130 keV, but no new levels were found that would influence the cross-section at stellar energies. The only new level found has a resonance energy of 448.5 ± 0.5 keV. An upper limit is placed on the strength of radiative capture by any missed levels. Angular distribution measurements, combined with the results of $N^{14}(\alpha, \alpha')$ by other workers, lead to an assignment $J^\pi = 2^-$ for the 448 keV resonance (7.966 MeV excitation). From the same target used for the $C^{13}(p,\gamma)$ measurements, the yield of $C^{12}(p,\gamma)$ radiation was measured, and the cross-sections of both reactions are extrapolated to stellar energies. The extrapolated cross-section factor $S_0$ at 25 keV c.m. proton energy is 6.0 ± 0.8 keV barn for the $C^{13}(p,\gamma)$ reaction, and is 1.33 ± 0.15 keV barn for the $C^{12}(p,\gamma)$ reaction. The equilibrium number of $C^{12}/C^{13}$ in the CNO-cycle is thus 4.1 ± 0.7 at a temperature of $15 \times 10^6$ °K.

4866 THE (p, d) REACTION AND INELASTIC SCATTERING OF PROTONS ON $Be^9$.
C.F.Nemets, L.S.Saltykov and M.V.Sokolov.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1663-4 (June, 1960). In Russian.
Angular distributions of protons elastically scattered on $Be^9$ nuclei and also of deuterons from the $Be^9(p, d)Be^8$ reaction were measured for incident proton energies of 6.8 MeV. [English translation in: Soviet Physics — JETP (USA), Vol. 11, No. 6, 1199-1200 (Dec., 1960)].

4867 RESONANCES IN THE REACTIONS $Si^{28}$ + p. J.C.Newton.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 529-41 (Dec. (3), 1960).

Resonances in the gamma-ray yield were observed at bombarding energies in MeV of 1.653 ± 0.005, 2.09 ± 0.015 and 2.30 ±0.015. They correspond to energy levels in $P^{29}$ at 4.320 ± 0.015, 4.74 ± 0.022 and 4.94 ± 0.022 MeV with total observed widths of 55.2 ± 2 keV, 14 ± 2 keV and less than 4 keV respectively. Capture gamma-radiation proceeding predominantly to the ground state of $P^{29}$ was observed from the two lower resonances. The 4.94 MeV resonance showed only radiation corresponding to that from the first excited state of $Si^{28}$. The angular distribution of the gamma-rays at the 1.65 MeV resonance shows that the 4.320 MeV state has spin $\frac{3}{2}$. Considerations of reduced widths indicate that it has odd parity and is of the "single particle" type. Strong interference effects were observed in the angular distribution at off-resonant energies. It seems likely that this interference occurs mainly with the hard-sphere part of the direct electric dipole capture process. A cross-section of (1.3 ± 0.4) $\mu$barns is obtained for this process at 1.65 MeV bombarding energy on the assumption that all of the interference arises from this source. A value of 1.75 ± 0.35 eV was obtained for the radiative width $\Gamma\gamma$ of the 4.320 MeV state. The angular distribution of the gamma-rays at the 2.09 MeV resonance was also shown to be anisotropic but the anisotropy may still be consistent with the previously reported spin of $\frac{1}{2}$+ for the 4.74 MeV state. A value of 0.9 ± 0.04 eV was obtained for the radiative width $(2J + 1)\Gamma\gamma$ of this state.

4868 $Si^{28}(p,p'\gamma)$ ANGULAR CORRELATIONS. H.F.Bowsher, G.F.Dell and H.J.Hausman.
Phys. Rev. (USA), Vol. 121, No. 5, 1504-8 (March 1, 1961).

Angular correlations were measured between protons scattered inelastically from a $Si^{28}$ target and the decay gamma rays from the 1.78 MeV first excited state of the target nuclei. The incident proton bombarding energy was varied between 5.8 and 7.0 MeV. The angular correlation experiments were performed for proton detector angles of 37°, 60°, 90°, and 120°. The measured angular correlation functions are all of the form $A + B \sin^2[2(\theta-\theta_0)]$, where $\theta_0$ is the axis of symmetry. When the incident proton beam energy was 7.0 MeV, the symmetry direction was found to be 90° (centre of mass) independent of the proton detector angle. These results agree with the prediction of a compound-nucleus theory. This suggests the existence of a strong compound nucleus resonance in $P^{29}$ at an excitation energy of 9.6 MeV. For lower proton beam energies, the symmetry direction, $\theta_0$, shifts with a change in the proton detector angle or a change in the proton beam energy. These results are consistent with a direct-reaction mechanism.

4869 EXCITATION FUNCTIONS OF (p,2 NUCLEON) REACTIONS. P.P.Strohal and A.A.Caretto, Jr.
Phys. Rev. (USA), Vol. 121, No. 6, 1815-22 (March 15, 1961).

Excitation functions for the (p,pn) reaction were determined in the energy range 250 to 440 MeV for the target nuclei $As^{75}$, $Br^{81}$, $Zr^{96}$, $I^{127}$, $Ce^{142}$, $W^{186}$, and $Re^{187}$. Both isomer products were determined in the case of the $Br^{81}(p,pn)Br^{80}$ reaction. Also, excitation functions were determined for the (p,2p) reaction on $Zr^{96}$, $Ce^{142}$, and $W^{186}$ and for the (p,2n) reaction on $Zr^{96}$. All cross-sections were measured relative to the $Al^{27}(p,3pn)Na^{24}$ excitation function. The (p,pn) excitation functions are only moderately sensitive to energy showing an increase by about 30% for iodine, 20% for arsenic and cerium, and a 12% decrease for zirconium. The remaining excitation functions are flat. The ratio of $\sigma(p,pn)$ to $\sigma(p,2p)$ is 1.62 ± 0.09, for the three targets measured, at 440 MeV. The various mechanisms for the production of reactions of this type are examined in the light of present understanding. The suggestion is made that, despite the relative insensitiveness of these excitation functions to energy, (p,pn) and (p,2p) reactions may take place by more than one mechanism in this energy region. A comparison is made with the results of recent Monte Carlo nuclear cascade calculations applied to calculation of (p,pn) reaction excitation functions.

# Due to Neutrons

4870 GAMMA-RAY SPECTRA FROM CAPTURE OF FAST NEUTRONS. I.Bergqvist and N.Starfelt.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 513-23 (Feb., 1961).

A method to study the spectrum of the gamma-rays emitted in radiative capture of fast neutrons was developed. A sodium iodide scintillation spectrometer was employed and the use of time-of-flight techniques made it possible to reduce the background of scattered neutrons sufficiently. Nickel, silver and gold were studied with 0.1 MeV neutrons and a comparison with the gamma-ray spectra from the capture of thermal neutrons was made. The agreement was good for nickel and silver. In the case of gold the relative intensity of the high-energy gamma-rays was lower for 0.1 MeV neutrons than for thermal neutrons.

4871 NEUTRON CAPTURE GAMMA-RAY SPECTRA OF THE NICKEL ISOTOPES. P.A.Treado and P.R.Chagnon.
Phys. Rev. (USA), Vol. 121, No. 6, 1734-9 (March 15, 1961).

The spectra of gamma radiation following pile-neutron capture in separated isotopes of nickel were measured with a three-crystal scintillation pair spectrometer as well as with a single-crystal scintillation counter. Energies and intensities of the gamma-rays from each isotope are reported. Each of the lines observed with natural nickel was assigned to $Ni^{58}(n,\gamma)Ni^{59}$, $Ni^{60}(n,\gamma)Ni^{61}$, or $Ni^{62}(n,\gamma)Ni^{63}$. In some cases, gamma-rays of nearly identical energies are found in two, or in all three, isotopes. Additional gamma rays not resolved in the natural nickel spectrum appear in $Ni^{58}(n,\gamma)Ni^{59}$ at 7.65 MeV, and in $Ni^{60}(n,\gamma)Ni^{61}$ at 7.65 MeV and in $Ni^{60}(n,\gamma)Ni^{61}$ at 4.70 and 5.55 MeV. The spectrum of $Ni^{62}(n,\gamma)Ni^{63}$ is dominated by a strong line at 6.80 MeV, presumably the ground-state transition.

4872 RADIATIVE CAPTURE CROSS-SECTIONS FOR 25 keV NEUTRONS.
V.N.Kononov, Yu.Ya.Stavisskii and V.A.Tolstikov.
Atomnaya Energiya (USSR), Vol. 5, 564 (1958). In Russian.

Radiative capture cross-sections for 25 keV Sb–Be photo-neutrons were measured by irradiating a sample with both fast and thermal neutrons, and measuring the induced activities with an end-window counter. Calibration was carried out with an $I^{127}$ sample. [English translation in: Reactor Science (GB), Vol. 11, No. 1, 46 (Nov., 1959)]. M.Hasan

THE POSSIBILITY OF USE OF THE (n, 2n) REACTION IN NUCLEAR SPECTROSCOPY. See Abstr. 4834

NEUTRON CROSS-SECTIONS OF Cd, Sm, Eu AND Gd. See Abstr. 4801

# Due to Mesons and Hyperons

4873 NEUTRONS FROM THE CAPTURE OF A POLARIZED MU MESON. E.Lubkin.
Ann. Phys. (USA), Vol. 11, No. 4, 414-82 (Dec., 1960).

The angular distribution of the neutrons from the capture by a spinless nucleus of a totally polarized muon in the 1s Bohr orbit is calculated via two single-particle nuclear models, termed "modified Fermi gas" and "square well." A direct 4-fermion coupling, with a left-handed neutrino, represents the weak interaction. The major results depend on the Fermi, Gamow–Teller, and pseudoscalar coupling constants: $c_F$, $c_G$, $c_P$. The angular distribution is $1 + \kappa(C_-/C_+)\cos\Theta$, where $\Theta$ is the angle from the muon's spin to the neutron's momentum,

$$C_\pm = |c_F|^2 \pm 2|c_G|^2 + |c_G - (p/2M)c_P|^2,$$

p is the neutrino's energy, M is the rest energy of a nucleon, and $\kappa$ is the calculated asymmetry reduction factor. The "modified Fermi gas" calculations, performed for $Ca^{40}$ and $Pb^{208}$, employ a Fermi sea of protons and $\mu^- + p \rightarrow \nu + n$ to produce neutrons at a localized zone of the nucleus, which are followed through the nuclear surface via geometrical optics. Those neutrons which escape at this stage of the calculation are termed "direct neutrons," and a $\kappa$ restricted to direct neutrons is ~ 0.7. Due to total internal reflection and attenuation, most neutrons do not escape directly. Captured neutrons are assumed to excite boil-off, which is isotropic and which strongly dominates the lower $\frac{2}{3}$ of the neutron energy spectrum. The top quarter of the spectrum is nevertheless relatively free from boil-off. The "square-well" calculations, performed for $O^{16}$, $Si^{28}$, and $Ca^{40}$, employ eigenfunctions of a real square well of finite depth for the nucleons, and a sperical harmonic expansion up to g-waves, inclusive, of the neutrino plane wave. $\kappa$ ranges from several to ~ 30 per cent. In such a single-particle model upper shells are found to dominate strongly captures with productions of free neutrons. The case of rarefied hydrogen is treated.

## ue to Deuterons

4874 COULOMB EXCITATION OF $Ge^{74}$ AND $Ge^{76}$. W.R.Wisseman and R.M.Williamson.
uclear Phys. (Internat.), Vol. 21, No. 4, 688-95 (Dec.(3), 1960).

Deuterons and protons with energies from 3.5 to 4.0 MeV were ed to excite the 598 keV level in $Ge^{74}$ and the 564 keV level in $^{76}$. The scattered particles were studied at angles from 75° to 0° with a magnetic analyser by using photographic plate detection. ne applicability of Coulomb excitation theory in this region of omic number and incident energy was tested by measuring the nergy dependence of the deuteron excitation cross-sections for th nuclei, the angular distribution of inelastically scattered euterons for $Ge^{74}$ and the ratios of the deuteron to the proton xcitation cross-sections. These data indicate that Coulomb xcitation theory may be applied for deuterons of less than 3.5 MeV nd protons of less than 4.0 MeV. The values of the reduced ansition probability, B(E2), of $Ge^{74}$ and $Ge^{76}$ are 0.32 ± 0.03 and 29 ± 0.03, respectively. The B(E2) value derived from 4.0 MeV euteron data for $Ge^{74}$ was 30% higher than the above value. Part this discrepancy may be due to departures from Rutherford cattering of the elastically scattered deuterons, as Rutherford cattering was assumed in deriving the inelastic cross-sections.

4875 REACTION MECHANISM STUDIES ON $Si^{28}(d,p)Si^{29}$. II. INTERFERENCE EFFECTS.
.A.Kuehner, E.Almqvist and D.A.Bromley.
uclear Phys. (Internat), Vol. 21, No. 4, 555-81 (Dec. (3), 1960).

For Pt I see Abstr. 2235 of 1961. Measurements bearing pon the mechanism for the $Si^{28}(d,p)Si^{29}$ reaction, including easurements of differential and total excitation functions and f angular distributions for the proton groups leading to the west three states of $Si^{29}$, were made for incident deuterons f energy 6-10.7 MeV and for proton detector angles 0°-155°. These easurements demonstrated a dominant direct interaction mplitude, with, however, a small residual compound system mplitude reflected in interference terms in the cross-section. The ffects of this interference are displayed by prominent resonance tructure in the excitation curves, particularly for proton angles ff the forward stripping peak. Upper limits of $< 15\%$ and $< 30\%$ were stablished for the intensity of the compound system contributions o the reaction cross-sections to the ground state and first two xcited states of $Si^{29}$, respectively. Angular distributions were found o have similar features over the energy range studied and to isplay diffraction structure which persists even at large angles. he angular positions of the structural features are well fitted by Butler theory, but with the observed envelope decreasing much ess rapidly with angle than does the prediction. It was empirically emonstrated that adequate fits are obtained by removing the angle ependence contained in the deuteron factor which appears in the Butler expression for the angular distribution. Reduced widths were btained using the methods of Amado and of Bowcock. A comparison f these reduced widths with values by the usual peak-fitting echnique demonstrated that the same relative reduced widths are iven by the three methods but that the absolute value obtained sing the Amado extrapolation is approximately a factor of two less han that obtained with the other two techniques.

4876 NUCLEAR STRUCTURE STUDIES IN THE TIN ISOTOPES WITH (d,p) AND (d,t) REACTIONS.
B.L.Cohen and R.E.Price.
Phys. Rev. (USA), Vol. 121, No. 5, 1441-56 (March 1, 1961).

The neutron single-particle states in the odd isotopes of tin are identified by (d,p) angular distribution studies. The cross-sections for exciting these states by (d,p) and (d,t) reactions were measured and the results are analysed to give values of $V_j^2$ (in the Kisslinger—Sorenson notation), the fraction by which each of the single-particle states is full, for each subshell in each of the single-particle states is full, for each subshell in each isotope. These are used to calculate $\epsilon_j$, the unperturbed single-particle energies; the results are reasonably consistent. If the observed energies of single-particle states are used to predict the $V_j$, the agreement is generally good, but some discrepancies are noted and an explanation is offered. Other weakly excited states are found in the region of the single-particle states. At higher excitation energies, several rather sharp levels are strongly excited in (d,p) reactions. Their energy, cross-section, and regularities among the isotopes suggests that these are single-particle levels from the next major shell ($82 < N \leq 126$); however, their angular distributions cannot be used for identification as they are the same for all levels in this region and show little structure. This last fact is not easily explained. Some of the two quasi-particle excitation states in the even isotopes of Sn are identified and the apparent pairing energy is thereby measured; it is surprisingly found to vary rapidly with mass number. Spectra from (d,p) and (d,t) reactions in isotonic pairs $Cd^{114}$-$Sn^{116}$ and $Cd^{116}$-$Sn^{118}$ are compared to show that the single-particle neutron states are much more radically affected by the addition of two protons than by the addition of two neutrons, contrary to the usual assumption in shell model theory. Q values for (d,p) and (d,t) reactions on the major isotopes of tin are measured.

4877 ENERGY LEVELS IN $Zr^{91}$ EXCITED BY THE (d,p) REACTION. R.L.Preston, H.J.Martin, Jr and M.B.Sampson.
Phys. Rev. (USA), Vol. 121, No. 6, 1741-4 (March 15, 1961).

Eleven energy levels in $Zr^{91}$ were excited. The excitation energies of the levels are 0, 1.22, 2.07, 2.19, 2.56, 2.84, 3.05, 3.25, 3.45, 3.65 and 3.87 MeV. Angular distributions were measured for the first four levels and assignments were made using the shell-model and the Butler stripping theory. The assignments are $2d_{5/2}$ for the ground state, $3s_{1/2}$ for the 1.22 MeV state, $2d_{3/2}$ for the 2.07 MeV state, and $1g_{7/2}$ for the 2.19 MeV state. The application of the Butler theory to the data gave reasonable and useful fits. The ground-state Q value was measured and is 5.02 ± 0.03 MeV.

## Nuclear Fission

4878 ON THE THEORY OF NUCLEAR FISSION. I. THE NUCLEAR EXCHANGE FORCES BETWEEN THE FRAGMENTS. W.Brunner and H.Paul.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 267-78 (1960). In German.

The Fong—Newton theory is modified by the explicit consideration of the nuclear exchange forces between the fission fragments. The fission probabilities are now identified with the probability of penetration of the potential well of the combined nuclear and Coulomb forces. The magnitude of the nuclear forces is determined so that the mass distribution of the fragments agrees with experimental values. It is shown that increases in these nuclear forces and the kinetic energy of the fragments are connected with the formation of closed shells. D.H.Lord

4879 THE MECHANISM OF EMISSION OF PROMPT FISSION NEUTRONS. V.N.Nefedov.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1657-62 (June, 1960). In Russian.

Reports measurements of the spectra of fission neutrons emitted at certain angles with respect to the direction of flight of the fragments (0 and 180°; 40 and 120°; 90°). The spectra of neutrons emitted by light and heavy fragments were compared. The kinetic energy and temperature of the light and heavy $U^{235}$ fission fragment groups at the instant of emission of fission fragments were also determined. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1195-8 (Dec., 1960)].

4880 PREDICTIONS OF SPONTANEOUS FISSION HALF-LIVES FOR HEAVY NUCLEI. D.W.Dorn.
Phys. Rev. (USA), Vol. 121, No. 6, 1740 (March 15, 1961).

Swiatecki's work (Abstr. 1512 of 1956) on correlation of spontaneous fission half-lives is modified and extended to include elements beyond Z = 100. The values of spontaneous fission half-lives predicted on these bases are unexpectedly high. For example, the partial half-life for Z = 106, A = 271 is predicted to be about 13 years.

4881 THE KINETIC ENERGY OF FISSION FRAGMENTS. W.Brunner and H.Paul.
Z. Naturforsch. (Germany), Vol. 15a, No. 12, 1109-10 (Dec., 1960). In German.

An attempt is made to relate the mean kinetic energy of fission fragments produced by thermal neutrons in heavy elements to a shell-structure-dependent deformation of the fragments at the instant of production. It is shown that the maxima of the kinetic energy are simply connected with the appearance of "magic" fission products. S.J.St-Lorant

4882 AN APPROACH TO THE SYSTEMATICS OF DELAYED NEUTRON PRECURSORS. A.C Pappas and G.Rudstam.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 353-66 (Dec. (1), 1960).

A review of the theory of delayed fission neutron emission probabilities is given and the expectations critically surveyed. The upper Z limits of the region where delayed neutron emission is energetically favoured are estimated throughout the table of nuclides and has led to a systematics of delayed neutron precursors. The average distance of the delayed neutron precursor (Z,N) from the stable charge $Z_{N-1}$ of the isotones of the delayed neutron emitter $(Z+1, N-1)$, i.e.$(Z_{N-1} - Z)$ increases from light to heavy nuclides.. The effect of closed nucleon shells is very pronounced. Just above neutron shell edges the upper Z limit is drawn towards stability. This effect increases with higher neutron shells.

4883 RADIOCHEMICAL STUDY OF THE RANGES IN METALLIC URANIUM OF THE FRAGMENTS FROM THERMAL NEUTRON FISSION. J.B.Niday.
Phys. Rev. (USA), Vol. 121, No. 5, 1471-83 (March 1, 1961).

The mean ranges in uranium of 28 fission products were determined by radiochemical measurement of the fraction escaping from the surface. Several factors affecting the precision and accuracy of the method are discussed. A semiempirical equation is developed which gives an excellent correlation between the ranges of fragments from a specific mass chain and their average initial velocity. The average total kinetic energy of the fragment pairs is about 30 MeV less for the products of symmetrical fission than is expected from comparison with the asymmetrical products. The low momenta of the symmetrical fragments are not readily explained by particle emission unless the concept of isotropic neutron evaporation is abandoned. The results may be interpreted by assuming that the symmetrical and asymmetrical products result from two modes of fission which involve different critical shapes of the fissioning nucleus, and that the choice between modes is dependent on the closing of the 50-proton shell in the heavy fragment. The 10% decrease in range observed for two shielded nuclides is also examined in some detail.

# NUCLEAR POWER STUDIES

4884 MATERIALS FOR NUCLEAR ENGINEERS. Edited by A.B.McIntosh and T.J.Heal.
London: Temple Press (1960) 373 + ix pp.

A comprehensive survey of the published information on the properties of some of the fuel and structural materials used in the cores of thermal reactors. Individual chapters, each written by an author working in the field concerned, deal with the following fuels: metallic uranium, thorium and plutonium and ceramic fuels [mainly oxide and carbide]. A further chapter deals with graphite and the three remaining chapters with the canning materials: magnesium, beryllium, zirconium and their alloys. Each chapter is written on a similar pattern, dealing first with the occurrence, extraction and preparation of the material, especially insofar as any trace impurities resulting from a particular method may affect the subsequent performance of the material. An account is then given of the compatibility with other materials, fabrication and handling problems. Finally the effect of reactor conditions on the material is considered, though comparatively few data on irradiation effects are available for most materials. Each chapter has an appendix summarizing the available data, that for plutonium containing, for example, equilibrium diagrams for sixteen alloys and basic crystallographic data for other alloys. Extensive bibliographies give sources of published data: some previously unpublished material is included. The book is well illustrated with plates and numerous diagrams and tables. R.D.Smith

4885 PULSED NEUTRON SYSTEM FOR REACTOR MEASUREMENTS.
R.D.Kelly, J.C.Hamilton and L.C.Beavis.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 178-83 (Feb., 1961).

A complete pulsed neutron system has been developed for use in reactor reactivity measurements. The probe unit is small enough to fit into a reactor instrumentation pipe. The pulse-to-pulse variation in neutron output has been kept to a minimum by regulating the gas pressure in the neutron tube and by maintaining the same pulsing conditions regardless of pulsing rate. The total neutron output per pulse is in excess of $10^7$ neutrons, and the maximum pulsing rate is 10 pulses/sec. The neutron tube has a useful life of $10^6$ pulses. The system meets the design requirements; however, some additional work may be necessary if temperatures experienced during actual operation in the reactor affect the pressure regulating system of the tube.

4886 THE OPTIMUM PARAMETERS FOR THE THERMODYNAMIC CYCLE OF AN ATOMIC POWER STATION.
V.M.Datskovskii.
Atomnaya Energiya (USSR), Vol. 5, 460 (1958). In Russian.

It is assumed that the heat output along each channel of a reactor has a cosine distribution, that there is a maximum permissible fuel element temperature and it is possible to use several steam cycles. The analysis assumes a Rankine cycle with regeneration and the useful power of the plant is calculated. It is shown that to obtain maximum power output for a given total surface area of the fuel elements there is an optimum arithmetic mean temperature of the coolant in the reactor. [English translation in: Reactor Science (GB) Vol. 11, No. 1, 43-5 (Nov., 1959)]. J.F.Hill

4887 THE OAK RIDGE THERMONUCLEAR PROGRAM—RECENT ADVANCES ON THE DCX. J.L.Dunlap.
IRE Trans nuclear Sci. (USA), Vol. NS-7, No. 4, 19-25 (Dec., 1960).

In the Oak Ridge thermonuclear experiment, 600 keV molecular ions of hydrogen or deuterium are injected into the median plane of a direct current magnetic mirror machine (DCX). A fraction of the molecular ions is dissociated ($H_2^+ \rightarrow H^+ + H^0$) as the ion beam passes through a high-energy carbon arc whose electrodes are located at each end of DCX. The magnetic field configuration is such that the 300 keV atomic ions thus created are trapped by virtue of the change in charge-to-mass ratio and enter a circular orbit concentric with the magnetic axis. The neutral atoms and the remaining undissociated molecular beam leave the machine. Loss processes, principally charge exchange collisions suffered by the circulating ions, have thus far prevented achievement of the appreciable plasma density required for observable fusion reactions. Plasma densities in the order of $10^{+10}$ ions/cm$^3$ and mean containment times of 10 to 12 msec have been observed. The experimental programme at the present time is one of diagnostic measurements on the trapped ions and their environment, and of building up the plasma density by increasing the trapping rate and containment time.

4888 THE $\gamma$-RAY SPECTRUM FROM THE IRT REACTOR. L.V.Groshev and A.M.Demidov.
Atomnaya Energiya (USSR), Vol. 7, 257 (1959). In Russian.
English translation in: Reactor Science (GB), Vol. 12, No. 4, 219-20 (Aug., 1960).

The spectrum of $\gamma$-rays leaving the core of the IRT reactor through a horizontal channel was plotted using a Compton spectrometer. J.F.Hill

# ATOMIC AND MOLECULAR PHYSICS

4889 ON A RIGID-SPHERE MODEL IN THE THEORY OF DISPLACEMENT AND COLLISION BROADENING OF SPECTRAL LINES. ATTRACTIVE AND REPULSIVE RIGID SPHERES. F.Schuller and B.Vodar.
C.R. Acad. Sci. (France), Vol. 251, No. 19, 1997-9 (Nov. 7, 1960). In French.

A previously examined (Abstr. 2270 of 1961) rigid sphere model of collision broadening and displacement of spectral lines is refined to take attractive and repulsive potentials into account.

R.W.Nicholls

4890 ON THE SOLUTION OF THE HARTREE–FOCK EQUATION IN TERMS OF LOCALIZED ORBITALS. W.H.Adams.
J. chem. Phys. (USA), Vol. 34, No. 1, 89-102 (Jan., 1961).

The Hartree–Fock method is discussed with emphasis placed on the transformation properties of the Hartree–Fock equation. It is emphasized that the Hartree–Fock equation may be solved in terms of nonorthogonal one-electron functions, and that in some cases it may be more convenient to choose such solutions. Equations are developed which define the localized one-electron functions and it is shown how these equations may be solved. For a system of closed shell atoms or ions, it is suggested that the localized orbitals of each atom or ion can be expanded in terms of functions centred on its nucleus. This suggestion is based on the success of the ionic theory of crystals. Due to the symmetry of a crystal, it is suggested that use of the localized orbitals could lead to expressions for the first order, Hartree–Fock density matrix and the Hartree–Fock energy of a crystal, i.e., one could obtain the solution of the Hartree–Fock equation for a crystal.

4891 THE PROBLEM OF QUANTUM TRANSITIONS IN THE SELF-CONSISTENT FIELD APPROXIMATION. I.B.Bersuker.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 685-91 (Dec., 1960). In Russian.

Describes a new, more accurate, method of solving non-stationary problems in the self-consistent field approximation. The probability of a quantum transition in a many-electron system is obtained by solving a system of non-stationary equations of the self-consistent field, similar to Fok's [Fock's] equations for the stationary case. It is shown that the usual formula for transition probabilities is a zeroth approximation in matrix elements of the operator representing interactions between electrons. Optical dipole transitions in atoms are considered and first-approximation corrections are derived for them. [English translation in: Optics and Spectrosc. (USA)].

A.Tybulewicz

4892 THE STABILITY OF A WAVE-FUNCTION UNDER A PERTURBATION. G.G.Hall.
Phil. Mag. (GB), Vol. 6, 249-58 (Feb., 1961).

The concept of the stability of an atomic or molecular wave-function under a perturbation is defined and the properties which distinguish stable wave-functions are deduced. The stability of approximate wave-functions is particularly examined and a number of general results stated. Self-consistent wave-functions are shown to be stable under one-electron perturbations. The concept enables many hitherto isolated results to be unified and extended. In particular, a new method of calculating nuclear magnetic shielding constants for atoms is given. The concept also suggests means of improving an approximate wave-function so that the derived estimate of some property is made more accurate.

4893 HYPERFINE STRUCTURE OF E.P.R. SPECTRA FOR SINGLE ELECTRONS IN DOUBLE POTENTIAL WELLS. A.I.Burshtein.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 4, 886-9 (Dec. 1, 1960). In Russian.

A calculation of the hyperfine spectrum in electron spin resonance for an electron in a potential having two minima and a Fermi contact interaction with one or more nuclei in each well. The potential converting two isolated wells to a double one and the hyperfine interaction are treated as perturbations. The results depend on the relative magnitude of the effects of these two terms and are illustrated for nuclear spins $\frac{1}{2}$.

J.G.Powles

NUCLEAR QUADRUPOLE RESONANCE. REVIEW. See Abstr. 4742

## ATOMS

4894 CHARACTERISTICS OF THE TYPE OF ELECTRON CONFIGURATION OF ATOMS. V.M.Klechkovskii.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 655-8 (Nov. 21, 1960). In Russian.

In order to get a unique and general characteristic of the groups of configurationally analogous atoms a "configuration index" is defined. This index gives the number of holes in all the levels which belong to a group with a fixed value of $n + l$, which has at least one partly filled level. It is shown that this quantity is strictly periodic in the sense of the Mendeleev periodic system. Using the rule of successive filling of the $(n + l)$-groups and the exclusion principle, a dependence of the configuration index on Z is obtained.

F.Herbut

4895 ON THE GENERALIZED HARTREE AND FOCK METHODS.
Ya.I.Vizbaraite, T.D.Strotskite, and A.P.Yutsis.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 6, 1358-60 (Dec. 21, 1960). In Russian.

A discussion is given of the connection between the extended generalized Hartree method and the generalized Fock method for calculations of atomic energies. It is shown that working in the many-configurational approximation is equivalent to applying the variational method to a simpler situation. [English translation in: Soviet Physics–Doklady (USA)].

R.F.Peierls

4896 EVALUATION OF ELECTROSTATIC ENERGY LEVELS OF $f^6$. J.B.Gruber and J.G.Conway.
J. chem. Phys. (USA), Vol. 34, No. 2, 632-8 (Feb., 1961).

The 119 electrostatic energy levels for an $nf^6$ configuration are calculated for three different sets of Slater $F_K$ ratios: $4f^6$ hydrogenic – $F_4/F_2 = 0.1381$, $F_6/F_2 = 0.01511$; $5f^6$ hydrogenic – $F_4/F_2 = 0.1422$, $F_6/F_2 = 0.0161$; and $5f^6$ based on a Hartree–Fock calculation for the normal uranium atom - $F_4/F_2 = 0.159$, and $F_6/F_2 = 0.0204$. A tentative theoretical analysis of the absorption spectra of Eu IV can be made by using $\zeta = 1360\ cm^{-1}$ and $F_2 = 370\ cm^{-1}$. The results show clearly that the intermediate field matrices are essential to a quantitative analysis of the Eu IV and Am IV spectra and that Zeeman studies are needed to identify certain levels.

4897 ON LINE STRENGTH RELATIONS IN THE DOUBLET ARC SPECTRA OF ALUMINIUM, GALLIUM, INDIUM AND THALLIUM. W.Hanus.
Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys. (Poland), Vol. 8, No. 9, 629-36 (1960).

Extends to these atoms the calculation by Fermi (1930) of the first-order perturbation due to spin–orbit interaction of the valence electron in the alkali metals, explaining the departures from sum-rule predictions of the line strength ratios. The results are encouraging as far as the principal series is concerned for the lighter elements. In the other series, and for Tl, the results are not even qualitatively correct.

J.Hawgood

4898 AN INTEGRAL REPRESENTATION OF DISPERSION FORMULA FOR THE HYDROGEN ATOM IN THE GROUND STATE. M.N.Adamov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 315-17 (July 11, 1960). In Russian.

For abstract, see Abstr. 15639 of 1960. [English translation in: Soviet Physics–Doklady (USA), Vol. 5, No. 4, 771-3 (Jan.-Feb., 1961)].

4899 EFFECTS OF THE WEAK INTERACTION ON THE HYDROGEN ENERGY LEVELS. S.Goto and S.Machida.
Progr. theor. Phys. (Japan), Vol. 23, No. 2, 372-4 (Feb., 1960).

The lowest-order e–p potential arising from the $\beta$-decay coupling is calculated, with momentum cut-off K. The effects are unobservable if $K < 10^{17}$ cm$^{-1}$. R.J.N.Phillips

THEORETICAL DEMONSTRATION THAT A POSITRON WILL NOT FORM A BOUND STATE WITH A HYDROGEN ATOM.
See Abstr. 4263

G-FACTORS OF BROMINE AND CHLORINE. See Abstr. 3932

4900 THE nf AND ng LEVELS OF Ar II. L.Minnhagen.
Ark. Fys. (Sweden), Vol. 18, Paper 8, 97-132 (1960).

An analysis of the spectrum of singly ionized argon based on new observations in the whole 12 500-500 A range has given about 180 new energy levels. Some 120 of them belong to the $3p^4nf$ and ng configurations. The spectrum was excited by means of high-frequency pulses in a discharge tube containing argon gas at low pressure. The present part of the investigation is concerned with the nf and ng configurations. A pronounced pair coupling was observed for ng and an approximate pair coupling for nf. The combinations of nf with other configurations and those of ng with 4f were studied from an observational point of view as regards selection rules and estimated intensities. The $p^4$1 system belongs to the "two holes in a closed shell and one outer electron" configurations recently investigated theoretically by Möller. The comparison of observed level positions with the theoretical distribution shows good agreement for ng. In the case of nf the discrepancies are larger, which probably has to do with the much larger role played by non-diagonal energy matrix elements between levels with different values of n. On the basis of the theoretical results as regards the influence of non-diagonal matrix elements and the corresponding mixing of eigenfunctions an explanation is given for the apparent breakdown of the K selection rule for certain $(^3P)4f$-$(^3P)$ ng transitions. On the same basis the reliability of nf and ng series for an accurate determination of the ionization limit is discussed. The subsequent calculation of the $^3P_2$ limit from $(^3P_2)ng[6]6\frac{1}{2}$ involves an adjustment of the previously adopted value by about 28 cm$^{-1}$, which means that the $3p^4\,^3P_2$ ionization limit is 222 848.2 cm$^{-1}$ above the $3p^5\,^2P_1\frac{3}{2}$ groundlevel. An examination of the non-diagonal matrix elements between levels based on different parent levels shows that some series based on $^1D_2$ should exist above the $^3P_2$ limit. One pair of coincident levels, $(^1D_2)6g[6]6\frac{1}{2},5\frac{1}{2}$, has possibly been found.

4901 A DOUBLE RESONANCE EXPERIMENT ON THE $6^1P_1$ TERM OF THE EVEN BARIUM ISOTOPE IN THE Ba I SPECTRUM. H.Bucka and H.J.Schüssler.
Ann. Phys. (Germany), Vol. 7, No. 3-4, 225-32 (1961). In German.

Reports measurements of the change of intensity of resonantly scattered radiation ($\lambda$ = 5535 A) using polarizers in incident and scattered beams, a 60 Mc/s magnetic field and a variable magnetostatic field. The results give the lifetime of the $6^1P_1$ state as $1.04 \times 10^{-4}$ sec, the oscillator strength of the transition $6^1S - 6^1P_1$, f = 1.32 and $g_j$ = 1.025. G.F.Lothian

4902 THE HYPERFINE STRUCTURE OF EUROPIUM. I. K.Krebs and R.Winkler.
Ann. Phys. (Germany), Vol. 7, No. 1-2, 77-83 (1961). In German.

Measurements on the h.f.s. anomaly of $Eu^{151}$ and $Eu^{153}$ resonance lines are reported. The anomaly is probably attributable to exchange polarization. See also Abstr. 1804 of 1959. P.M.Parker

4903 THE QUADRUPOLE MOMENT OF EUROPIUM. K.Krebs and R.Winkler.
Naturwissenschaften (Germany), Vol. 47, No. 21, 490-1 (Nov., 1960). In German.

Hyperfine structures of the Eu II line $\lambda$3819 ($a^9S^0_4$–$z^9P_5$) were measured for $Eu^{151}$ and $Eu^{153}$. The B-factors for the splitting were determined for the term $z^9P_5$, which is especially suitable for the determination of quadrupole moments. From these and existing measurements, the quadrupole moments were derived as $+(0.95 \pm 0.1)$ barn for $Eu^{151}$ and $+(2.42 \pm 0.2)$ barn for $Eu^{153}$. Values in good agreement were obtained from the "intrinsic" quadrupole moment found from the Coulomb excitation of $Eu^{153}$. The ratio of the A-factors for the two isotopes in the Eu II ground state, $6sa^9S^0_4$, shows a hyperfine structure anomaly. J.Sheridan

4904 FAINT LINES IN THE ARC SPECTRUM OF IRON (Fe I). C.C.Kiess, V.C.Rubin and C.E.Moore.
J. Res. Nat. Bur. Stand. (USA), Vol. 65A, No. 1, 1-29 (Jan-Feb., 1961).

A search for new faint iron lines was made on spectrograms taken with an arc-in-air as source. The range of observations is from 2102 to 8679 A. The reciprocal dispersion of the spectrographs used for the various spectral regions varies from 1 A/mm to 3 A/mm. Twelve new energy levels were found, resulting in a total of 121 classified lines. A table containing 698 classified lines includes many lines whose wavelengths had been predicted as combinations among the known energy levels, and found in the solar spectrum in earlier work. Their reality is confirmed in the present work. A list containing 1102 newly measured unclassified lines is included. Many of the lines listed in the tables have been reported by other observers with varying degrees of accuracy. All such reference sources are indicated in the tables. As a result of the new measurements, these lines may safely be attributed to Fe I. A comparison of the new lines with the solar spectrum has resulted in the identification of 306 solar lines of Fe I unblended, and of 85 as blends to which Fe I is a contributor.

4905 ULTRAVIOLET SPECTRUM OF Ti I C.M.Wilson and M.P.Thekaekara.
J. Opt. Soc. Amer., Vol. 51, No. 3, 289-97 (March, 1961).

Four hundred and ten lines of the ultraviolet spectrum, from 2117 A to 3072 A, were measured in this study, with a probable error of 0.005 A, on high-dispersion quartz-prism spectrograms. small electronic computer, the Burroughs E101, was used to great advantage in calculating the wavelengths and wave numbers and in analysing the spectrum. Two new terms were discovered Two hundred and fourteen lines were classified, of which 152 were previously known. The energy values for 16 levels of seven previously known terms were revised.

4906 THE ISOTOPIC EFFECT IN THE THORIUM SPECTRUM E.A.Vernȳi and V.N.Egorov.
Optika i Spektrosk (USSR), Vol. 9, No. 6, 692-702 (Dec., 1960). In Russian.

The isotopic shift in the u.v. spectra of $Th^{232}$ and $Th^{229}$ was obtained; the even–odd effect was calculated and the deformation of the $Th^{229}$ nucleus was deduced. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

4907 SOME RESULTS OF A SPECTROSCOPIC STUDY OF V.H.F. PULSE DISCHARGES IN A RESTRICTED DISCHARGE GAP. V.V.Bakakina.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 784-6 (Dec., 1960). In Russian.

Reports time and pressure (1-100 mm Hg) dependences of the intensities of neon and helium lines excited in a narrow gap by decimetre radiowave pulses of 2-12 $\mu$sec duration. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

4908 INELASTIC COLLISIONS BETWEEN EXCITED AND NON-EXCITED POTASSIUM ATOMS. K.Hoffmann and R.Seiwert.
Ann. Phys. (Germany), Vol. 7, No. 1-2, 71-6 (1961). In German.

Potassium vapour was excited with one of the two potassium resonance lines. In the resulting fluorescence radiation both resonance lines were present due to inelastic collisions among the atoms of the vapour. The relative intensities of the two fluorescence components were measured as a function of temperature, and collision cross-sections were calculated. Radiation diffusion effects were taken into account. P.M.Parker

4909 ON THE RELATIVISTIC PHOTOEFFECT IN THE K-SHELL. B.C.H.Nagel.
Ark. Fys. (Sweden), Vol. 18, Paper 1, 1-28 (1960).

The relativistic K-shell photoeffect is analysed in terms of four "reaction amplitudes", which describe the process completely including all polarization effects. Expansions of these amplitudes in radial matrix elements are given. Using an improvement of the Sommerfeld–Maue final state wave-function, the amplitudes are computed to relative order $\alpha Z$ for a pure Coulomb field. Among effects obtained from the first-order terms are a non-zero forward emission intensity, and a transverse polarization of the photoelectrons, similar to that obtained in relativistic electron scattering.

4910 THE RELATIVISTIC PHOTOEFFECT AT THE K-SHELL THRESHOLD. B.C.H.Nagel and P.O.M.Olsson.
Ark. Fys. (Sweden), Vol. 18, Paper 2, 29-35 (1960).

The K-shell photoeffect is studied in the limit of zero kinetic energy of the outgoing photoelectron. The relativistic $(\alpha Z)^2$ corrections are obtained in the general case, and "exact" numerical calculations are performed for Z = 92. The total cross-section is reduced by 21% (for Z = 92), and the angular distribution is changed somewhat, compared to the non-relativistic results. Considerable electron polarization effects are obtained.

4911 THE SCATTERING OF ELECTRONS FROM THE LATTER POTENTIAL OF THE ATOM. T.Tietz.
Acta phys. Hungar., Vol. 12, No. 2, 163-5 (1960). In German.

Explicit expressions are given for the elastic scattering differential cross-section in the first Born approximation. The atomic potential employed is that of Latter (Abstr. 8169 of 1955). Numerical agreement with Hartree cross-sections for Z = 16 is relatively good. P.M.Parker

4912 SCATTERING OF ELECTRON BEAMS FROM NEUTRAL ATOMS FOR VARIOUS THOMAS–FERMI POTENTIALS. T.Tietz.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 262-6 (1960). In German.

Exact and approximate expressions for elastic scattering differential cross-sections are derived for three Thomas–Fermi type potentials. Numerical results are compared with Hartree values for the cross-sections. P.M.Parker

4913 SCATTERING OF SLOW ELECTRONS ON HELIUM ATOMS WITH EXCITATION OF $2^3S$ AND $2^1S$ LEVELS. I.M.Matora.
Optika i Spektrosk.(USSR), Vol. 9, No. 6, 707-12 (Dec., 1960). In Russian.

Drukarev's integral equations method (1953) is used to calculate the elastic S-scattering of electrons and the excitation functions for the $2^3S$ and $2^1S$ states of helium atoms bombarded with 0-40 eV electrons. The results are in quantitative agreement with experiment. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

BOUNDS ON SCATTERING PHASE SHIFTS FOR COMPOUND SYSTEMS. See Abstr. 4265

4914 THE FERMI–AMALDI THEORY OF THE POLARIZABILITY AND SUSCEPTIBILITY OF FREE ATOMS AND IONS. T.Tietz.
Ann. Phys. (Germany), Vol. 6, No. 3-4, 202-5 (1960). In German.

Polarizabilities are calculated for Ne, A, Kr and Xe, and the isoelectronic ions with one and two positive charges, employing the Kirkwood formula (Abstr. 2289 of 1932). In computing the mean of the square of the electron–nucleus distance, exchange and correlation corrections for the outer parts of the atom are represented by the Fermi–Amaldi correction. With appropriate approximations and boundary conditions, the desired mean is obtained as a simple closed formula. The diamagnetic susceptibilities of the same systems are also calculated on the same basis. Good agreement is obtained with the observed polarizabilities and susceptibilities, showing that this choice of electron distribution is a good approximation to the truth. J.Sheridan

SURFACE IONIZATION OF ATOMS OF INDIUM AND THALLIUM ON POLYCRYSTALLINE TUNGSTEN. See Abstr. 4568

# Isotopes

4915 TEMPERATURE-FLOAT METHOD FOR ISOTOPIC ANALYSIS OF HEAVY WATER WITHIN LOW CONCENTRATION RANGES.
E.Weingaertner, R.L.Datta, R.Kumar and E.G.Mahadevan.
Indian Institute of Science Golden Jubilee Research Volume (see Abstr. 2678 of 1961) p. 170-80.

The method employs the measurement of temperatures at which samples of different concentration of $D_2O$ have the same density. Use is made of a quartz float, the density of which does not show appreciable variation with temperature within a range of $\pm 3^\circ$C. The equilibration temperature (i.e., the temperature at which the density of water is equal to that of the quartz float) for different samples of water of known $D_2O$ concentration are determined, and a calibration curve plotted. This curve is used for assessing the concentration of unknown sample, the equilibration temperature of which was experimentally determined. The results, when compared with those of a mass spectrometer, show fairly good agreement.

4916 THE SEPARATION OF DEUTERIUM ON AN INDUSTRIAL SCALE BY LOW-TEMPERATURE DISTILLATION.
M.P.Malkov, A.G.Zel'dovich, A.B.Fradkov and I.B.Danilov.
Progress in cryogenics, Vol. 2 (see Abstr. 4509 of 1961) p. 69-86.

The development of the Soviet process is described. The problems involved the development of an economical refrigeration cycle, experimental investigations of the hydrodynamical operating conditions of the rectification column and of heat transfer, and the development of thermal insulation, methods for removing nitrogen, and methods of analytical control. The pilot and industrial plants are described. J.B.Birks

4917 ON THE SPECTROSCOPIC METHOD FOR THE QUANTITATIVE DETERMINATION OF $N^{15}$ IN NITROGEN. H.Zahn.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961), p. 58-62. In German.

Photographic intensity comparisons were made for bands of $N^{14}$ and $N^{15}N^{14}$ at 3159 and 3165 A respectively. For $N^{15}/N^{14} > 1.2\%$, the error is 2%. The h.f. discharge used is described. G.F.Lothian

4918 ISOTOPIC COMPOSITION OF XENON FROM ENSTATITE CHONDRITES. J.H.Reynolds.
Z. Naturforsch. (Germany), Vol. 15a, No. 12, 1112-14 (Dec., 1960).

It is found that the enstatite chondrites exhibit a uniform xenon spectrum with a very prominent excess of $Xe^{129}$ and with secondary anomalies similar to those found in the Richardton and carbonaceous chondrites. S.J.St-Lorant

# Mesic Atoms

4919 RADIATIONLESS TRANSITIONS IN HEAVY $\mu$-MESIC ATOMS.
M.Ya.Balatz, L.N.Kondrat'ev, L.G.Landsberg, P.I.Lebedev, Yu.V.Obukhov and B.Pontekorvo [Pontecorvo].
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1715-19 (June, 1960). In Russian.

The spectra of mesic X-ray photons emitted by $\mu$-mesic atoms of uranium and lead were studied with a scintillation spectrometer. It is shown that the $2P \rightarrow 1S$ radiative transition rate per stopped muon is appreciably smaller in mesic uranium than in lead. This indicates a hitherto unobserved radiationless transition mechanism in which the transition energy is transferred directly to the nucleus. [English translation in: Soviet Physics–JETP (USA), Vol. 11, No. 6, 1239-41 (Dec., 1960)].

# MOLECULES

4920 ENERGY TRANSFER WITH SPECIAL REFERENCE TO BIOLOGICAL SYSTEMS.
Disc. Faraday Soc. No. 27, 272 pp. (1959).

A general discussion was held at Nottingham University on April 14-16, 1959. Over 200 scientists were present, and 25 papers were read in two sections: (1) Modes of energy transfer from excited and unstable ionized states; (2) Energy migration in organized biological systems. Abstracts of some of the papers will appear in subsequent issues of Physics Abstracts.

4921 THE CUBIC ANHARMONIC POTENTIAL FUNCTION OF POLYATOMIC MOLECULES. L.Henry and G.Amat.
J. molecular Spectrosc. (USA), Vol. 5, No. 4, 319-25 (Oct., 1960).

A general expression is given for the anharmonic cubic potential function of axially symmetric molecules. The nonvanishing coefficients are given in a table where results for asymmetric and linear molecules are also included.

4922 QUANTUM MECHANICAL THREE-BODY PROBLEM. I. FOUNDATIONS.
H.Diehl, S.Flügge, U.Schröder, A.Völkel and A.Weiguny.
Z. Phys. (Germany), Vol. 162, No. 1, 1-14 (1961). In German.

The problem is treated in appropriate coordinates. These are, besides those of the centre-of-mass, the distances between the

three particles and three Eulerian angles, fixing in space the position of the triangle formed by the particles. The Hamiltonian can be simplified by introducing the usual angular momentum operators of a gyrating rigid body. The solution of the wave-equation is discussed. Factorization into an angular part and a part depending on the particle distances only leads to certain linear combinations of such products. The angular parts have the form of the representation coefficients $\mathcal{D}^{L}_{MK}$ of the three-dimensional rotational group. The parts depending on the distances may be derived from a system of differential equations coupling, in two separate sets, either even or odd values of K for each given value of L.

4923 QUANTUM MECHANICAL THREE-BODY PROBLEM. II. NONLINEAR TRIATOMIC MOLECULES.

S.Flügge and A.Weiguny.
Z. Phys. (Germany), Vol. 162, No. 1, 15-20 (1961). In German.

The results (see preceding abstract) are specialized to triatomic molecules in which the three atoms are allowed only small vibrations about their equilibrium positions. This restriction to the vibrational amplitudes makes a perturbation calculation suitable. A sketch of the zero-order approximation is given, and it is shown — at least for a symmetrical molecule of the type $AB_2$ — how the limiting case of the rigid body may be obtained for which there exist the formulae of Wang (Abstr. 67 of 1930).

4924 NEW CALCULATION OF THE BINDING ENERGY OF THE HYDROGEN MOLECULAR ION.

H.Diehl and S.Flügge.
Z. Phys. (Germany), Vol. 162, No. 1, 21-7 (1961). In German.

The procedure described by Diehl et al. (see preceding abstracts) is specialized to the ground state in which the eigenfunction only depends upon the three distances between the particles. The solution of the Schrödinger equation is approximated by variational methods, using the electronic functions of Finkelstein and Horowitz (Abstr. 1836 of 1928) and of Guillemin and Zener (Abstr. 2934 of 1929), but including the nuclear vibration in the trial function.

4925 $O_2$ VIBRATION RELAXATION IN OXYGEN–ARGON MIXTURES. M.Camac.

J. chem. Phys. (USA), Vol. 34, No. 2, 448-59 (Feb., 1961).

This and the following abstract discuss the use of a new experimental technique for the determination of $O_2$ vibration and dissociation rates. The concentration of $O_2$ in the ground vibrational state can be inferred from measurements of ultraviolet light transmission at 1470 A. $O_2$ has a strong continuous absorption band in this vacuum ultraviolet region. The vibrational relaxation rate of $O_2$ in shock-heated $O_2$–Ar mixtures was obtained from 1200° K to 7000° K. For Ar–$O_2$ collisions, the measured relaxation time $\tau_V$, can be fitted by the Landau-Teller theory:

$$1/\tau_V = nC_1T^{1/6}[1 - \exp(-2228T)]\exp[-(C/T)^{1/3}],$$

where n is the number of particles /cc and T is the temperature in deg K. $C_1 = 1.2 \times 10^{-7}$ cc/particle-sec-(deg K)$^{1/6}$ and $C = 1.04 \times 10^7$ (±30%)° K. The observed vibrational relaxation time for $O_2$–$O_2$ collisions is 5.0 ± 0.5 times faster than that for $O_2$–Ar collisions. The experimental results are compared to the theoretical predictions of Schwartz and Herzfeld (Abstr. 348 of 1953; 7605 of 1954). At the lower temperatures, the $O_2$–$O_2$ rates given by Blackman [J. Fluid Mech., Vol. 1, 61 (1956)] have a different temperature dependence than the $O_2$–Ar rates obtained in this experiment.

4926 $O_2$ DISSOCIATION RATES IN $O_2$–Ar MIXTURES. M.Camac and A.Vaughan.

J. chem. Phys. (USA), Vol. 34, No. 2, 460-70 (Feb., 1961).

Experimental measurements of the $O_2$ dissociation rate in shock-heated oxygen–argon mixtures were obtained with the ultraviolet light absorption technique described in the preceding abstract. The dissociation rate constant $k_{Ar}$ for the reaction $O_2 + Ar \rightarrow O + O + Ar$ can be fitted over the temperature range from 3400 to 7500° K by the theoretical formula $k_{Ar} = C(D/RT)^{n-1/2}\exp(-D/RT)$ where $C = 6.0 \times 10^1 \pm 20\%$ cc/mole-sec and $n = 1.5 \pm 0.2$. D = 5.116 eV is the oxygen dissociation energy; R is the gas constant; and T is the temperature. This result is compared with the classical collision theory and the theories of Wigner and Keck. The rates for the dissociation of $O_2$ by O and $O_2$ were also determined; compared to the argon rate constant $k_O \cong 25k_{Ar}$, $k_{O_2} <\sim 3k_{Ar}$. The experimental results are compared with those of Byron and Matthews. The relaxation times for dissociation and vibration are observed to be comparable at about 8000° K. The experimental data indicate that the dissociation rate above 8000° K is at least a factor of two less than the expected rate when the vibration is not in equilibrium (the vibrational temperature being less than the translational temperature) during dissociation.

4927 VIBRATIONAL PERTURBATION THEORY. I.M.Mills.

J. molecular Spectrosc. (USA), Vol. 5, No. 4, 334-40 (Oct., 1960).

Expressions are derived for the Jacobian of the Coriolis $\zeta$ interaction constants and the centrifugal stretching constants ($D_J$, $D_{JK}$, etc.) with respect to the force constants in a vibrating-rotating molecule.

4928 GROUP VIBRATIONS. I. METHODS. W.T.King and B.Crawford, Jr.

J. molecular Spectrosc. (USA), Vol. 5, No. 6, 421-44 (Dec., 1960).

Many complex molecules contain "characteristic groups", such as $CH_3$, whose group frequencies and approximate vibrational modes are reasonably well-known in advance of calculation. A method is desirable whereby these "group vibrations" may be eliminated from the vibrational problem once and for all, in advance, and whereby the reduced problem of "framework" vibrations may be simply written down without considering the complete molecular problem. This paper presents such a method. Constructions are given by which effective masses of the group atoms and adjusted group force constants may be determined such that a reduced secular equation for the framework vibrations alone may be derived. The methyl group is used as an example.

4929 DETERMINATION OF CORRECTIONS FOR NON-RIGIDITY IN CALCULATION OF HIGHER ROTATIONAL LEVELS OF ASYMMETRIC-TOP MOLECULES. G.A.Khachkuruzov.

Optika i Spektrosk. (USSR), Vol. 9, No. 6, 721-7 (Dec., 1960). In Russian.

A relation between centrifugal displacements of rotational levels in asymmetric-top molecules and the rotational quantum number J is established graphically. It is shown how to correct experimental values of rotational levels of asymmetric-top molecules and how to find higher rotational levels which cannot easily be measured. [English translation in: Optics and Spectrosc. (USA)].

A.Tybulewicz

4930 MICROWAVE SPECTRAL SERIES OF DEUTERATED HYDROGEN PEROXIDE.

J.T.Massey, C.I.Beard and C.K.Jen.
J. molecular Spectrosc. (USA), Vol. 5, No. 5, 405-15 (Nov., 1960).

Two spectral series of the $\Delta J = 0$ type have been recognized from some 130 microwave spectral lines observed in deuterated hydrogen peroxide. The method of identifying the members of a series is based upon the knowledge of the Stark and Zeeman splitting and the presence of a smooth functional relationship for the line frequencies in the series. An interpretation of the measured rotational magnetic moments leads to the conclusion that $HDO_2$ is the most probable origin of both series.

4931 MICROWAVE SPECTRUM OF IBr AND THE DETERMINATION OF THE MOLECULAR AND NUCLEAR PARAMETERS. T.S.Jaseja.

J. molecular Spectrosc. (USA), Vol. 5, No. 6, 445-57 (Dec., 1960).

The microwave spectrum of IBr corresponding to the transitions $J = 4 \rightarrow 5$ and $J = 5 \rightarrow 6$ for the two isotopic species $I^{127}Br^{79}$ and $I^{127}Br^{81}$ was investigated. The spectrum obtained could be well explained on the basis of the theory given by Bardeen and Townes. The necessary secular equations were developed and solved and the frequencies of the lines corresponding to the expected transitions were calculated. The agreement between the calculated and the observed frequencies is satisfactory. The analysis of the spectrum yields the following molecular and nuclear parameters: $B_e(IBr^{79}) = 1682.22 \pm 0.1$ Mc/s; $B_e(IBr^{81}) = 1656.51 \pm 0.1$ Mc/s; $\alpha_e(IBr^{79}) = 10.49 \pm 0.1$ Mc/s; $\alpha_e(IBr^{81}) = 10.26 \pm 0.1$ Mc/s; $(eQq)_{Br^{79}} = 722 \pm 15$ Mc/s; $(eQq)_{Br^{81}} = 603 \pm 15$ Mc/s; $(eQq)_{I^{127}} = 2731 \pm 60$ Mc/s. The two different values of $B_e$ for $IBr^{79}$ and $IBr^{81}$ yield a bond distance in IBr = 2.485 A.

4932 SPECTROSCOPY OF FLUORINE FLAMES. I. HYDROGEN–FLUORINE FLAME AND THE VIBRATION–ROTATION EMISSION SPECTRUM OF HF.

D.E.Mann, B A.Thrush, D.R.Lide, Jr, J.J.Ball and N.Acquista.
J. chem. Phys. (USA), Vol. 34, No. 2, 420-31 (Feb., 1961).

The hydrogen fluoride vibration–rotation emission spectrum from a hydrogen-fluorine diffusion flame was studied under high dispersion from 3200 $cm^{-1}$ in the infrared to about 5500 A in the visible

Measurements were made on the rotational lines in 23 bands including (1-0), (2-1), and (3-2) of the $\Delta v = 1$ sequence; (2-0), (3-1), (4-2), (5-3), and (6-4) of $\Delta v = 2$; (3-0), (4-1), (5-2), and (6-3) of $\Delta v = 3$; (4-0), (5-1), (6-2), (7-3), (8-4), and (9-5) of $\Delta v = 4$; and (5-0), (6-1), (7-2), (8-3), and (9-4) of $\Delta v = 5$. Complete rotational and vibrational analyses were carried out. The constants $B_v$, $D_v$, and $H_v$ are given for v = 0 to 9. The data were extensive and precise enough to warrant an extended Dunham treatment from which coefficients could be determined, including those for terms in $(v + \frac{1}{2})^5$ and $J^4(J + 1)^4$. Band centres for 22 bands and the vibrational term values $E_v$ for v = 0 to 9 are given.

4933 INFRARED SPECTRUM OF $Co(CO)_3NO$.
R.S.McDowell, W.D.Horrocks, Jr and J.T.Yates.
J. chem. Phys. (USA), Vol. 34, No. 2, 530-4 (Feb., 1961).

The infrared spectra of $Co(CO)_3N^{14}O$ and $Co(CO)_3N^{15}O$ vapour are reported from 10 000 to 280 $cm^{-1}$ and all fundamentals assigned. The two C—O stretches and the N—O stretch are at 2108, 2047, and 1822 $cm^{-1}$, respectively. Exchange with $C^{13}O$ indicates that a strong band at 2010 $cm^{-1}$ is due to the $C^{13}$—O stretch of the isotopic species $Co(CO)_2(C^{13}O)NO$. A normal coordinate treatment is carried out, and the force constants determined.

4934 INFRARED SPECTRUM AND THERMODYNAMIC PROPERTIES OF RUTHENIUM TETROXIDE.
M.H.Ortner.
J. chem. Phys. (USA), Vol. 34, No. 2, 556-8 (Feb., 1961).

The infrared spectrum of liquid ruthenium tetroxide was determined over the range 300 to 5000 $cm^{-1}$. Fundamental bands were observed at 330 and 913 $cm^{-1}$, and were assigned to the infrared active $\nu_3(F_2)$ and $\nu_4(F_2)$ vibrations. A combination band $[\nu_3 + \nu_1](F_2)$ at 1792 $cm^{-1}$ permitted on assignment of the Raman-active $\nu_1(A_1)$ frequency in agreement with earlier work. The final $\nu_2(E)$ Raman-active fundamental was calculated by the OVFF method, and the set of observed and calculated frequencies were utilized to calculate thermodynamic functions for the ideal gas from 298.16° K to 1000° K.

4935 INFRARED SPECTRUM OF LITHIUM FLUORIDE MONOMER BY MATRIX ISOLATION. M.J.Linevsky.
J. chem. Phys. (USA), Vol. 34, No. 2, 587-90 (Feb., 1961).

A method has been developed which can be used to observe the infrared spectrum of high temperature vapours. It combines the techniques of matrix isolation with that of Knudsen effusion. The infrared spectrum of matrix isolated lithium fluoride was observed in argon, krypton, xenon, and nitrogen matrices. The observed frequencies in the various matrix materials are shifted approximately 7% to 14% from the measured gas fundamental at 900 $cm^{-1}$. These shifts can be explained by the interactions of the trapped molecule with its surrounding neighbours, based on a model which estimates the change in magnitude of the electrostatic, inductive, and dispersive interactions during the course of a molecular vibration. These effects are particularly large in lithium fluoride due to its sizable dipole moment.

4936 VIBRATIONAL SPECTRA OF INORGANIC MOLECULES. I. ANTIMONY PENTACHLORIDE, ANTIMONY TRICHLORIDE, ZIRCONIUM TETRACHLORIDE, AND FERRIC CHLORIDE. J.K.Wilmshurst.
J. molecular Spectrosc. (USA), Vol. 5, No. 5, 343-54 (Nov., 1960).

The infrared spectra of $SbCl_5$ and $FeCl_3$ vapours from 700-190 $cm^{-1}$, $ZrCl_4$ vapour from 1000-190 $cm^{-1}$ and $SbCl_3$ vapour from 420-190 $cm^{-1}$ were obtained and assignments made. The data for $FeCl_3$ are consistent with a dimeric molecule having an out-of-plane bridge structure of the aluminium trichloride type. Statistical thermodynamic functions were computed from the assigned fundamentals for $SbCl_5$ and $SbCl_3$ and used to interpret the equilibrium for the reaction

$$SbCl_5(g) = SbCl_3(g) + Cl_2(g),$$

giving $\Delta E_0^\circ = 13750 \pm 260$ cals $mole^{-1}$. Statistical thermodynamic functions were also computed for $ZrCl_4$.

4937 ORIGIN OF THE GREEN BANDS IN THE BORON—OXYGEN SYSTEM.
W.E.Kaskan, J.D.Mackenzie and R.C.Millikan.
J. chem. Phys. (USA), Vol. 34, No. 2, 570-4 (Feb., 1961).

A study was made of the effect of oxygen on the intensity of absorption in the green or "fluctuation" bands by the gas phase in equilibrium with $B_2O_3(l)$. The reaction which forms the substances responsible for the bands from $B_2O_3(l)$ in the presence of oxygen was found to be 70 kcal/mole endothermic, in the range 1660-1950°K, in agreement with other work. At constant temperature the absorptivity was found to depend on the $\frac{1}{4}$ power of the oxygen pressure. This is interpreted as evidence that the absorbing species is $BO_2$. The oscillator strength of the transition is estimated as 0.003.

4938 AN INVESTIGATION OF THE ELECTRONIC SPECTRA AND THE ISOTOPIC SHIFT OF COMPOUNDS OF BORON AND OXYGEN. III. $\gamma$-BANDS OF THE BO MOLECULE.
A.A.Mal'tsev, D.I.Kataev and V.M.Tatevskii.
Optika i Spektrosk.(USSR), Vol. 9, No. 6, 713-20 (Dec., 1960). In Russian.

The $\gamma$-band system of $B^{11}O$ and $B^{10}O$ molecules was recorded between 1600 and 2090 A. The system was shown to be due to a $C^2\Pi—X^2\Sigma^+$ transition. The spectrum was interpreted and vibrational constants were calculated. A preliminary rotational analysis of five bands is given. Correlation of the electronic states of BO with the atomic states of B and O is discussed. Accurate wavelengths of the atomic lines of boron and silicon between 1360 and 2090 A are listed. [English translation in: Optics and Spectrosc. (USA)].
A.Tybulewicz

4939 ZERO-FIELD SPLITTING OF MOLECULAR ZEEMAN LEVELS. R.McWeeny.
J. chem. Phys. (USA), Vol. 34, No. 2, 399-401 (Feb., 1961).

Electron spin—spin coupling, responsible for zero-field splitting of Zeeman levels, may be discussed very generally by means of a "coupling anisotropy function" defined in terms of the components of the two-electron density matrix. The properties of this function are fully discussed elsewhere: the present note is concerned with zero-field splitting of triplet levels and with the series of approximations which lead from the general results to simple (orbital theory) approximations. A numerical calculation on the phosphorescent triplet states of naphthalene gives reasonable agreement with experiment.

4940 SPIN DENSITY IN PYRENE NEGATIVE ION.
G.J.Hoijtink, J.T.Townsend and S.I.Weissman.
J. chem. Phys. (USA), Vol. 34, No. 2, 507-8 (Feb., 1961).

Improved resolution permits assignment of all proton hyperfine coupling constants in pyrene negative ion. The results are acounted for by a simple calculation of configurational interaction.

4941 ELECTRONIC STRUCTURES AND SPECTRA OF SOME NITROGEN—OXYGEN COMPOUNDS. K L.McEwen.
J. chem. Phys. (USA), Vol. 34, No. 2, 547-55 (Feb., 1961).

The electronic structures and spectra of nitrite ion, nitrosomethane, nitrosamine, and nitrate ion are calculated by a semi-empirical method, which includes both the $\pi$-electron system and, in a more limited manner, the $\sigma$-electron system. The calculated transition energies and intensities for the first three compounds above agree fairly satisfactorily with experiment. For nitrate ion, however, it seems possible that the lowest observed transition may be a very low energy $n \rightarrow \sigma^*$ transition, $\sigma^*$ being an antibonding $\sigma$ orbital, rather than one of the $n \rightarrow \pi^*$ transitions considered in the present work.

4942 MOLECULAR ELECTRONIC INTEGRALS FOR CYCLIC SYSTEMS. J.de Heer and R.Pauncz.
J. molecular Spectrosc. (USA), Vol. 5, No. 4, 326-33 (Oct., 1960).

Using the Mulliken approximation to compute all interelectronic repulsion integrals over atomic orbitals, a compact formula is derived which gives all relevant molecular integrals for cyclic systems in terms of (i) their Coulomb integrals and (ii) the normalization constants of the molecular orbitals involved. It is stressed that the simplicity of the present equations, and of similar results obtained in earlier investigations, is due to symmetry restrictions to a larger extent than is commonly acknowledged. A brief numerical analysis for benzene leads to a critical comparison with alternative approximation methods. Some other possible applications of the present formulae are suggested.

4943 NUCLEAR HYPERFINE INTERACTIONS IN ORBITALLY DEGENERATE STATES OF AROMATIC IONS.
H.M.McConnell and A.D.McLachlan.
J. chem. Phys. (USA), Vol. 34, No. 1, 1-12 (Jan., 1961).

The dynamical Jahn—Teller effect in the benzene negative ion is investigated by estimating the vibronic eigenfunctions and energies for the lowest energy degenerate and lowest energy non-degenerate vibronic states using Hückel molecular orbital theory and the normal coordinates for the 606 $cm^{-1}$ and 1595 $cm^{-1}$ $E_{2g}$ vibrations of benzene given by Whiffen. It is concluded that the lowest energy vibronic state is doubly degenerate, and that this degeneracy

is removed by interactions with a polar solvent when this ion is in solution. The solvent interaction produces a time-dependent oscillation or switching of the electronic spin distribution relative to the nuclear framework, which in turn leads to an enhanced broadening of the hyperfine structure through a corresponding fluctuation in the isotropic hyperfine interaction. The calculated linewidths are the same as those reported by Townsend and Weissman if the switching spin distribution is described by a correlation time of the order of $10^{-9}$ sec. A similar effect is probably responsible for the anomalously broad proton hyperfine structure reported by Weissman and Townsend in the negative ions of coronene and triphenylene. This effect must also contribute to the linewidth of the hyperfine structure of the negative ion of cyclo-octatetraene observed by Katz and Strauss. It is suggested that the enhanced spin–lattice relaxation rate reported by Weissman and Townsend for the negative ion of coronene is due to enhanced spin–orbit interaction, also associated with a degeneracy of the ground vibronic state.

4944 CALCULATION OF THE DIAMAGNETIC SUSCEPTIBILITY OF $N_2$. H.F.Hameka.
J. chem. Phys. (USA), Vol. 34, No. 2, 366-8 (Feb., 1961).

The diamagnetic susceptibility of the nitrogen molecule is calculated from wave-functions that are constructed from gauge invariant atomic orbitals. The result is $-13.539 \times 10^{-6}$ which agrees satisfactorily with the average experimental value $-13.3 \times 10^{-6}$.

4945 VALENCE BOND TREATMENT ON THE B STATE OF THE HYDROGEN MOLECULE.
C.S.Tschudi and N.V.Cohan.
J. chem. Phys. (USA), Vol. 34, No. 2, 401-4 (Feb., 1961).

The potential energy of the lowest $^1\Sigma_u^+$ state of the hydrogen molecule is given as a function of the internuclear distance. Calculations are carried out by the valence bond method using Slater 1s and 2p atomic orbitals. Both ionic and covalent structures are considered. The 1s orbitals of the ionic and covalent functions include a variational parameter but the orbital exponent of the 2p orbital is kept constant. It is found that the introduction of the 2p orbital into the wave-function results in a considerable improvement of the dissociation energy and that further the state is essentially covalent in character rather than ionic, as previously reported.

4946 BONDING IN CUBIC COMPLEXES. J.H.Macek and G.H.Duffey.
J. chem. Phys. (USA), Vol. 34, No. 2, 682-3 (Feb., 1961).

Symmetry arguments yield the general spdf $\sigma$ bond orbitals for A in cubic $AB_8$. The valence orbitals needed include 1s, 3np, 3d and (4 – 3n)f. The greatest strength, 3.934, is found when n is 27/55. Incomplete hybridization, splitting of valence levels of A, and $\pi$ bonding in a cubic field are also discussed.

4947 SPIN–ORBIT COUPLING IN ORBITALLY DEGENERATE STATES OF AROMATIC IONS. H.M.McConnell.
J. chem. Phys. (USA), Vol. 34, No. 1, 13-16 (Jan., 1961).

It is shown that in the orbitally degenerate ground state of the benzene negative ion there is a first-order electron spin–orbit interaction associated with the electronic orbital motion around the ring. This first-order interaction may be as large as a few $cm^{-1}$ and can give rise to enhanced electron spin–lattice relaxation in solution even though most of the time the electronic orbital motion is strongly quenched by electrostatic interaction with the solvent.

4948 ELECTRON SPIN RESONANCE OF SOME VANADYL PORPHYRINS.
E.M.Roberts, W.S.Koski and W.S.Caughey.
J. chem. Phys. (USA), Vol. 34, No. 2, 591-3 (Feb., 1961).

The electron spin resonance spectra of the vanadyl complexes of etioporphyrin II, vanadyl mesoporphyrin IX dimethyl ester, and deuteroporphyrin IX dimethyl ester were studied and found to be identical to within experimental error. Unlike the corresponding copper complexes, the vanadyl complexes give no observable nitrogen hyperfine effects. An explanation is proposed for the lack of this hyperfine structure, and an approximate method is suggested for evaluating the bonding parameters.

4949 THEORY OF PROTON COUPLING CONSTANTS IN UNSATURATED MOLECULES. M.Karplus.
J. Amer. Chem. Soc., Vol. 82, No. 16, 4431-2 (Aug. 20, 1960).

When $\pi$-electron terms are included in the coupling interaction, a quantitative explanation of the seemingly large values of 1.5-7 c/s obtained for coupling constants between protons separated by three or four carbons is obtained. W.J.Orville-Thomas

4950 $N^{14}$ PURE QUADRUPOLE RESONANCES OF SEVERAL NITRILES. H.Negita and P.J.Bray.
J. chem. Phys. (USA), Vol. 33, No. 6, 1876-7 (Dec., 1960).

The quadrupole coupling constants and field gradient asymmetry parameters are reported for $CCl_3CN$, 4-$C_5H_4N(CN)$, 2-$C_5H_4N(CN)$ and $C_6H_5CN$, and the results discussed qualitatively in terms of the molecular structures. E.F.W.Seymour

4951 N.M.R. SPECTRA OF 1,1,4,4-TETRAMETHYLCYCLOHEXYL-CIS AND TRANS-2,6-DIACETATE.
J.I.Musher.
J. chem. Phys. (USA), Vol. 34, No. 2, 594-7 (Feb., 1961).

High resolution spectra were studied and a series of coupling constants obtained which are compared with values predicted by theory. Relative chemical shifts of equatorial and axial protons are also given.

4952 NUCLEAR QUADRUPOLE COUPLING IN THE $NH_3$ MOLECULE. Y.Kato.
J. chem. Phys. (USA), Vol. 34, No. 2, 619-24 (Feb., 1961).

The electric field gradient q at the position of the nitrogen nucleus in the $NH_3$ molecule is evaluated by using four representative molecular orbitals expressed as linear combinations of atomic orbitals. The integrals over atomic orbitals are carried out by the method of Barnett and Coulson. When the electric quadrupole moment $Q(N^{14})$ of the nitrogen nucleus is determined from the experimental nuclear quadrupole coupling constant eQq, all $Q(N^{14})$ values obtained fall into the range of values already found by several authors. The most reliable computed value of $Q(N^{14})$ may be $0.94 \times 10^{-26}$ $cm^2$, which can be obtained from the wave-function including configuration interaction given by Kaplan. The polarization effect of the inner shell pointed out by Sternheimer is also evaluated by the use of Slater atomic orbitals. There is some discussion about the bond equivalent orbitals of $NH_3$.

4953 STABILITIES OF GASEOUS MOLECULES IN THE Pb–Se AND Pb–Te SYSTEMS. R.F.Porter.
J. chem. Phys. (USA), Vol. 34, No. 2, 583-7 (Feb., 1961).

Mass spectrometric analyses of the vaporization products of phases near compositions PbSe and PbTe indicate that these substances vaporize primarily as molecular PbSe(g) and PbTe(g), respectively. Ion fragmentation processes originating from electron bombardment of vapours effusing from a conventional Knudsen cell interfere with quantitative determination of thermochemical dissociation energies of PbSe(g) and PbTe(g). The use of double oven-type Knudsen cells provided a means for the study of the dissociation of PbSe(g) and PbTe(g) into the gaseous elements. Dissociation energies of PbSe(g) and PbTe(g) were found to be 61.5 ± 2.5 and 51.4 ± 2.0 kcal/mole, respectively. The dissociation energy of $Te_2$(g) was found to lie close to the published spectroscopic value.

DISSOCIATION OF $H_2^+$ AND $D_2^+$. See Abstr. 4564

4954 DIPOLE MOMENTS OF HYDROCARBONS. D.R.Lide, Jr.
J. chem. Phys. (USA), Vol. 33, No. 6, 1879 (Dec., 1960).

In spite of the recent criticisms of Dewar and Schmeising [Tetrahedron, Vol. 5, 166 (1959)] it is concluded that hyperconjugation is necessary as a partial explanation of the dipole moments of unsaturated hydrocarbons. W.J.Orville-Thomas

4955 MOLECULAR COLLISIONS. II. DIATOMIC MOLECULES. G.Gioumousis and C.F.Curtiss.
J. math. Phys. (USA), Vol. 2, No. 1, 96-104 (Jan.-Feb., 1961).

For Pt I see Abstr. 1846 of 1959. A set of coupled integral equations describing the collisions of diatomic molecules is developed by exploitation of the properties of the irreducible representations of the three-dimensional rotation group. An expansion of the cross-section in spherical harmonics is described, and its virtues argued.

4956 MOLECULAR STATISTICS OF VINYL POLYMERS. Y.Suzuki.
J. chem. Phys. (USA), Vol. 34, No. 1, 79-82 (Jan., 1961).

A formula is proposed to describe the end-to-end distance and the total dipole moment of the vinyl polymer $(CH_2CHX)_n$. The interaction of neighbouring X's is taken into account. The formula treats the general atactic polymer and includes the isotactic polymer and the syndiotactic polymer as special cases.

4957 QUANTUM CALCULATIONS OF THE VELOCITY DEPENDENCE OF THE DIFFERENTIAL AND TOTAL CROSS SECTIONS FOR ELASTIC SCATTERING OF MOLECULAR BEAMS. R.B.Bernstein.
J. chem. Phys. (USA), Vol. 34, No. 2, 361-5 (Feb., 1961).

The partial wave treatment (phase shift analysis) of the elastic scattering of molecular beams (Abstr. 17860 of 1960) is applied to the calculation of the velocity dependence of the differential and total cross-sections for an assumed Lennard-Jones (12, 6) potential. For most of the calculations, the $\epsilon$, $\sigma$ values are chosen to correspond to the H –Hg system. The range of the velocity parameter $A \equiv k\sigma = \mu v\sigma/\hbar$ is from 3 to 30; this is equivalent to a 100-fold variation in H beam temperature (approx. 8.2-820° K). Computations of the angular distribution of the scattering $d\sigma(\theta)/d\Omega$ and the total cross-section Q as a function of A are reported. A correlation of the interference maxima in $d\sigma(\theta)/d\Omega$ is presented. The Massey–Mohr approximation for Q(A) for an inverse sixth-power attractive potential is compared with the present calculations for the Lennard-Jones (12, 6) potential. Significant undulatory deviations are noted at low A; this effect is attributed to the existence of the broad maximum in the phase-shift curve $\eta(l)$, which, in turn, originates from the negative repulsive phases at low $l$. Consideration is given to the question of the sensitivity of the scattering to the repulsive part of the potential.

4958 MULTIPLE APERTURE SLITS FOR MOLECULAR BEAM SOURCES. S.Datz, R.E.Minturn and E.H.Taylor.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 210 (Feb., 1961).

4959 THEORY OF THE pp$\mu$ MOLECULAR ION. S.Flügge and U.Schröder.
Z. Phys. (Germany), Vol. 162, No. 1, 28-33 (1961). In German.

Using the variational method developed by Diehl and Flügge (1961), the binding energy and molecular parameters of the muon molecule are calculated. The vibrational amplitudes of the protons turn out to be much larger in comparison with their equilibrium distance than in the electronic molecule $H_2^+$. The equilibrium distance is about 40% larger than it would have come out from a simple two-centre calculation with fixed nuclei. A dissociation energy of 211 eV is found; this value may be increased by something between 10 and 20 eV in consequence of plausible corrections.

# SOLID-STATE PHYSICS

4960 A SOLID STATE spd-MOLCAO TREATMENT OF CUBIC-OCTAHEDRAL $CaB_6$ WITH VARIATION OF THE d ORBITAL EXPONENT. S.Flodmark.
Ark. Fys. (Sweden), Vol. 18, Paper 4, 49-64 (1960).

The present work is a direct continuation of previous work (see Abstr. 6246 of 1959), and includes the correction of a numerical mistake, which, however, does not change the main qualitative conclusions. The energy bands were computed for five different choices of the d orbital exponent. The result of these new calculations indicates that a remarkable increase in the d orbital exponent, when chosen according to the Slater rules, is required to minimize the energy.

4961 THE TRANSITION TO THE METALLIC STATE. N.F.Mott.
Phil. Mag. (GB), Vol. 6, 287-309 (Feb., 1961).

An account is given of the theory that a crystalline or non-crystalline array of atoms will make a transition from the metallic to the non-metallic state as the interatomic distance is varied. Experimental evidence relevant to the theory is summarized. Wigner's (1938) suggestion that an electron gas might crystallize at sufficiently low densities is examined, and an experiment suggested by which it might be tested.

4962 FORCE FIELD IN THE CRYSTALLINE STATE AND THE FOURIER MATRIX OF ALKALI HALIDES. N.Boccara.
C.R. Acad. Sci. (France), Vol. 251, No. 22, 2505-7 (Nov. 28, 1960) In French.

A general expression is given for the Fourier matrix of crystals of alkali halides of the type NaCl. The resultant force field is considered as being the sum of three components; (1) the Coulomb forces, (2) forces due to the penetration of the electronic atmosphere of the ions, and (3) the van der Waal's forces. The Fourier matrix has 11 parameters. Many of these parameters may be derived from experimental values of elasticity coefficients, infrared absorption frequencies, etc. J.Iball

4963 ON THE NATURE OF THE CRYSTAL FIELD APPROXIMATION. C.M.Herzfeld and H.Goldberg.
J. chem. Phys. (USA), Vol. 34, No. 2, 643-51 (Feb., 1961).

A new method is developed for the treatment of molecular interactions, and is applied to a system consisting of a hydrogen atom in a 2p state and a hydrogen molecule in the ground state. The interaction of these two species is calculated using ordinary crystal field theory and also the new method. A comparison of the results shows some of the shortcomings of the conventional crystal field theory, and provides corrections to it. The new method consists of (1) expanding all electron terms of the total Hamiltonian for the system which involve interactions between the atom and all the molecule, thus transforming the interaction Hamiltonian into sums of products of one-electron operators, and (2) of using properly antisymmetrized wave-functions made up of products of atom and molecule eigenfunctions. The calculations show the effect of the neglect of overlap and exchange in ordinary crystal field theory.

METHODS OF NUCLEAR ORIENTATION. See Abstr. 4827

LIMIT OF STABILITY OF CRYSTALLINE HELIUM. See Abstr. 4529

# LATTICE MECHANICS

4964 A STUDY OF THE LATTICE VIBRATIONS OF TELLURIUM BY THE METHODS OF GROUP THEORY. Yu.L.Rabotnikov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2095-108 (Sept., 1960). In Russian.

For abstract, see Abstr. 20737 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1879-90 (March, 1961)].

4965 USE OF THE DENSITY-MATRIX METHOD IN DEALING WITH CONDUCTION ELECTRONS INTERACTING WITH LATTICE VIBRATIONS. I.G.Lang.
Fiz tverdogo Tela (USSR), Vol. 2, No. 9, 2330-40 (Sept., 1960). In Russian.

For abstract, see Abstr. 2377 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2077-86 (March, 1961)].

4966 A STUDY OF SOME TEMPERATURE EFFECTS ON THE PHONONS IN ALUMINIUM BY USE OF COLD NEUTRONS. K.E.Larsson, U.Dahlborg and S.Holmryd.
Ark. Fys. (Sweden), Vol. 17, Paper 21, 369-92 (1960).

Using the cold neutron scattering technique, about 300 phonons were determined in a single aluminium crystal at room temperature to define 10 pairs of dispersion curves. Investigations were made of the variation of frequencies, phonon line widths and multi-phonon spectra in the temperature range $293 \leq T \leq 932°$ K. For a particular direction in the crystal lattice it is shown that the frequencies vary about 15% over this temperature range. The line widths are of such a magnitude that the derived phonon mean free paths vary from about 5 phonon wavelengths at 600° K to about 1.5 phonon wavelengths at 930° K. The observed multi-phonon spectra are found to agree with calculated differential cross-sections in the incoherent approximation.

4967 SCATTERING OF ELECTRONS ON THE ACOUSTIC MODES OF LATTICE VIBRATIONS IN HEXAGONAL CRYSTALS. E P.Pokatilov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2210-13 (Sept., 1960). In Russian.

For abstract, see Abstr. 2376 of 1961. [English translation in: Soviet Physics—Soviet State (USA), Vol. 2, No. 9, 1973-5 (March, 1961)].

ACOUSTIC SPIN RESONANCE IN METALS. See Abstr. 5074

# Thermal Properties

ANOMALOUS SPECIFIC HEAT DISCONTINUITY AT THE SUPERCONDUCTING CRITICAL TEMPERATURE OF Al, Ga AND Zn. See Abstr. 4533

4968 THE CALCULATION OF DEBYE CHARACTERISTIC TEMPERATURES. N.M.Wolcott.
Proc. Phys. Soc. (GB), Vol. 77, Pt I, 218 (Jan., 1961).

Comments are made on a paper (Abstr. 915 of 1961) in which elastic constants are used to calculate $\theta_0$ for a number of solids.
J.W.Leech

4969 THERMAL EXPANSION OF $\alpha$-Sn, InSb AND CdTe. S.I.Novikova.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2341-4 (Sept., 1960). In Russian.

For abstract, see Abstr. 916 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2087 (March, 1961)].

4970 THERMAL EXPANSION AND RELATED BONDING PROBLEMS OF SOME III–V COMPOUND SEMICONDUCTORS. L.Bernstein and R.J.Beals.
J. appl. Phys. (USA), Vol. 32, No. 1, 122-3 (Jan., 1961).

The thermal expansion coefficients were measured for the antimonides, phosphides, and arsenides of gallium and indium over the temperature range 20-650°C except for InSb (to 500°C) and GaSb (to 400°C). Agreement with previous work is good except for GaSb where the expansion coefficient is found to be $6 \times 10^{-9}$ instead of $6.9 \times 10^{-6}$ as found by Welker and Weiss [Solid State Physics. New York: Academic Press (1956), Vol. III, p. 51.].
C.A.Hogarth

4971 THERMAL EXPANSION OF ALUMINIUM AT LOW TEMPERATURES. E.Huzan, C.P.Abbiss and G.O.Jones.
Phil. Mag. (GB), Vol. 6, 277-85 (Feb., 1961).

The thermal expansion of aluminium was determined by a sensitive optical method between 100°K and 15°K, i.e. down to temperatures below $\Theta_D/20$. At the lowest temperatures the Grüneisen parameter shows a significant rise. The results are discussed from the point of view of the theory of lattice vibrations.

4972 EFFECTS OF A MAGNETIC FIELD ON HEAT CONDUCTION IN SOME FERRIMAGNETIC CRYSTALS. D.Douthett and S.A.Friedberg.
Phys. Rev. (USA), Vol. 121, No. 6, 1662-7 (March 15, 1961).

The thermal conductivities of single-crystal bars of several ferrites were measured over the temperature range 1.4° to 25°K in both zero external magnetic field and in a field of about 9.4 kOe. For each specimen the zero-field conductivity is a smooth function of the temperature over the entire range considered. The magnitudes of the conductivities of the manganese and cobalt-zinc ferrite specimens are quite low, approx. 1.5 mW $cm^{-1}$ $(degK)^{-1}$ at 4°K. Upon application of a magnetic field parallel to the direction of heat current flow, the conductivities of the manganese ferrite and cobalt-zinc ferrite specimens are increased. The magnetoconductivities are rather large. For example, $\Delta K/K_0 = 0.2$ for manganese ferrite at 2°K. Such a field produces no detectable change in the conductivity of the manganese-zinc ferrite. The experimental results are interpreted on the basis of the assumption that the heat current is primarily a phonon current limited by phonon–magnon scattering.

4973 THERMAL CONDUCTIVITY OF SUPERCONDUCTORS IN THE INTERMEDIATE STATE. N.V.Zavaritskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1673-84 (June, 1960). In Russian.

The thermal conductivity of lead, tin and gallium in the intermediate state was measured between 0.15 and 3°K. It was found that transition to the intermediate state was accompanied (provided heat was transferred by phonons) by an increase of the thermal resistance $\Delta W_{gi}$ which was proportional to $T^{-3}$ throughout the whole temperature interval. The magnitude of $\Delta W_{gi}$ was found to approach that calculated on the assumption that phonons are scattered on conduction electrons in normal-state domains. In the case of heat transfer by electrons an increase of the thermal resistance, $\Delta W_{ei}$, depended weakly on the amount of impurities in a sample. The variation of $\Delta W_{ei}/W_{es}$ with $T/T_c$ is similar for all three metals. With change of temperature from $0.4\,T_c$ to $0.9_c$ this ratio decreases approximately 30 times. At temperatures below $0.4\,T_c$ the value of $\Delta W_{ei}$ is close to that calculated under the assumption that the electron mean free path is limited by the domain boundaries. [English translation in: Soviet Physics — JETP (USA), Vol. 11, No. 6, 1207-14 (Dec., 1960)].

# ELECTRON STATES

4974 APPEARANCE AND EFFECT OF THE DEBYE–WALLER FACTOR IN THE TRANSPORT COEFFICIENTS OF SIMPLE NORMAL METALS. M.Bailyn.
Phys. Rev. (USA), Vol. 121, No. 5, 1336-43 (March 1, 1961).

Analogous to the theory of the diffraction of X-rays and neutrons by the lattice vibrations of crystals, the scattering of electrons in a metal by thermal vibrations gives rise to a temperature-dependent Debye–Waller factor in the matrix element. The factor is derived and its possible effects on electrical resistivity discussed for the case where Bloch functions are used for the electron wave-function. A detailed numerical calculation for an umklapp process involving a particular phonon was performed, for caesium at room temperature, with the result that the new matrix element is about 0.7 times the 1937 Bardeen result, and consequently the contribution to the resistivity about 0.5 times the Bardeen value. It is even a possibility that, for some phonons, the matrix element may increase.

4975 THE BAND STRUCTURE AND ELECTRONIC PROPERTIES OF GRAPHITE CRYSTALS.
R.R.Haering and S.Mrozowski.
Progress in semiconductors. Vol. 5 (see Abstr. 5008 of 1961) p. 273-316.

The band structures of two-dimensional and three-dimensional graphite are discussed, and the applications of the band model to diamagnetic susceptibility, the de Haas–van Alphen effect, cyclotron resonance, optical absorption and reflection, the electronic specific heat, the non-oscillatory and oscillatory Hall effect, and magnetoresistance are considered. Related studies on the thermoelectric effect and electrical conductivity, paramagnetic resonance absorption, rhombohedral graphite, graphite compounds, lattice vacancies and radiation damage are described. 93 refs. J.B.Birks

4976 SYMMETRY OF ENERGY BANDS IN CRYSTALS OF THE SnSe AND $Sb_2S_3$ TYPE. F.M.Gashimzade.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2070-6 (Sept., 1960). In Russian.

For abstract, see Abstr. 930 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1856-62 (March, 1961)].

4977 APPLICATION OF THE FREE-ELECTRON THEORY TO THREE-DIMENSIONAL NETWORKS. J.A Hoerni.
J. chem. Phys. (USA), Vol. 34, No. 2, 508-13 (Feb., 1961).

The free-electron network theory is generalized to permit its application to covalent and metallic crystals. General expressions for the case where the various branches of the network have different lengths and potentials are derived. Delta function discontinuities of potential at the junctions of the branches are introduced to describe the effective field acting on valence electrons. The general equation can be applied to various special cases, such as the Kronig and Penney potential or the behaviour of $\pi$ electrons in planar organic molecules. The free-electron network theory is used to derive the energy band structure of diamond in the interpolation scheme proposed by Slater. Energy band features are in semiquantitative agreement with those obtained by other methods. Some discrepancies in the sequence of energy levels in different theories are pointed out. The discussion includes the possible application of the free-electron network theory to more complicated crystals.

4978 d BANDS IN CUBIC LATTICES. III. J.Callaway.
Phys. Rev. (USA), Vol. 121, No. 5, 1351-6 (March 1, 1961).

For Pt II, see Abstr. 17912 of 1960. A simple model of an ionic crystal is considered, consisting of a lattice of point changes $(Z_1e)$ and $(Z_2e)$ arranged in the rocksalt structure, and screened by a uniform distribution of negative charge. This lattice defines a periodic potential in which electron energy levels are calculated. The energies of five states pertaining to the d-band are calculated, by expansion in symmetrized combinations of plane waves, as functions of the average binding and relative ionicity.

4979 STRUCTURE OF HOLE BANDS IN ALKALI CHLORIDES. T.E.Kucher and K.B.Tolpygo.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2301-9 (Sept., 1960). In Russian.
For abstract, see Abstr. 931 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2052-9 (March, 1961)].

STRUCTURE OF THE HOLE BAND OF TELLURIUM. See Abstr. 5048

4980 BINDING AND DECAY OF A MOTT EXCITON TAKING INTO ACCOUNT THE EXACT COULOMB FUNCTIONS. A.A.Lipnik.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2044-7 (Sept., 1960). In Russian.
For abstract, see Abstr. 20778 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1835-8 (March, 1961)].

4981 IDENTIFICATION OF EXCITONS WITH LIGHT WAVES IN A CRYSTAL AND A MACROSCOPIC THEORY OF EXCITONS WITH AND WITHOUT ACCOUNT OF RETARDATION. S.I.Pekar.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1786-97 (June, 1960). In Russian.
Excitons are identified with light waves in crystals. The theory of excitons is reduced to a macroscopic theory of light waves. The boundaries of exciton energy bands, exciton limiting energies for $k \to 0$, effective masses etc. are expressed in terms of a permittivity tensor $\epsilon(\omega, k)$. On going over to the limit $c \to \infty$ the usual exciton theory results are obtained, in which no allowance is made for retardation of the interaction between crystal particles and which are based on the Schrödinger equation. When the electromagnetic wave accompanying an exciton is longitudinal, retardation can be neglected. If, on the other hand, the attendant wave possesses a vortex field, allowance for retardation affects appreciably the results in the regions where the refractive index is not very large and leads to exciton energies and effective masses which differ from those derived from the Schrödinger equation. Crystals of various symmetries are considered. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1286-93 (Dec., 1960)].

BOUND STATE OF AN EXCITON IN InSb AT A POSITIVELY CHARGED IMPERFECTION. See Abstr. 4263

# DEFECT PROPERTIES

4982 DENSITY OF VACANCIES IN IRON—CHROMIUM ALLOYS. M.A.Krishtal.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 720-6 (Nov., 1960). In Russian.
Reports a determination of the density of vacancies in $\gamma$-iron and its alloys with 0.85-5.72% Cr. This determination was based on measurements of the electrical resistance and internal friction, which gave comparable results. With increase of the chromium content the energy of activation of vacancy formation increased and the density of vacancies decreased.
A.Tybulewicz

4983 CONCERNING THE DISTRIBUTION OF IMPURITIES IN ALKALI-HALIDE CRYSTALS. I.Ya.Melik-Gaikazyan, E.K.Zavadovskaya and M.N.Treskina.
Kristallografiya (USSR), Vol. 5, No. 3, 477-8 (May-June, 1960). In Russian.
Measurements are reported of the optical absorption of NaCl and KCl containing lead impurity introduced as $PbCl_2$. Two impurity-induced absorption peaks in each case are attributed to lead atoms at normal lattice sites and at special sites such as surface sites on mosaic blocks. The relative heights of the normal-site absorption peaks are in qualitative agreement with the relative solubilities of $PbCl_2$. Further supporting evidence is obtained from changes in electrical conductivity and from optical absorption in melt-grown and solution-grown KCl. [English translation in: Soviet Physics—Crystallography (USA), Vol. 5, No. 3, 456-8 (Nov.-Dec., 1960)].
J.Holt

4984 REGULAR PILE-UP OF DISLOCATIONS IN $\alpha$-IRON. E.Smith.
Acta metallurgica (Internat.), Vol. 8, No. 6, 403-4 (June, 1960).
Data are presented on the rare observation with $\alpha$-iron of a regular pile-up of dislocations in a thin foil specimen. The dislocations were piled up against a precipitate particle and it was deduced from electron diffraction data and the morphology of the precipitate particles that they were lying in a (110) plane. The Burgers vector could not be determined, but it is reasoned that it was along the [111] direction. A.E.Kay

DISLOCATIONS IN ROLLED PLATES OF SILVER CHLORIDE. See Abstr. 4016

4985 ELECTRON MICROSCOPE OBSERVATION OF DISLOCATIONS IN TALC. S.Amelinckx and P.Delavignette.
J. appl. Phys. (USA), Vol. 32, No. 3, 341-51 (March, 1961).
Dislocations in talc appear to be dissociated into four partial dislocations separated by their stacking fault ribbons. This phenomenon can easily be interpreted in terms of the known structure of talc. The stacking fault energy can be estimated from the equilibrium condition of the four partials. Complicated networks resulting from the interactions of ribbons are observed. A number of striking contrast effects are also described.

4986 DIRECT ELECTRON MICROSCOPY OF THIN FOILS OF INTERNALLY OXIDIZED DILUTE COPPER ALLOYS. M.F.Ashby and G.C.Smith.
Phil. Mag. (GB) (Eighth Ser.), Vol. 5, 298-301 (March, 1960).
0.25% Al copper alloy, rolled to 200$\mu$ thickness, was internally oxidized by placing in $Cu_2O$ and heating for 20 min at 950°C so producing a dispersion of alumina in pure copper. Electro-thinning in a methyl alcohol/conc. nitric acid bath, (potential 9V and temperature -20°C) gave foils suitable for electron microscopy. Contrast effects in unstrained foils are discussed in terms of the different coefficients of thermal expansion giving rise to strain fields. In foils strained 0.5 to 6.0%, jogged dislocations and triangular dislocation loops attached to the alumina particles are observed. The loops are regarded as prismatic in character and a mechanism for their development is outlined. R.Reed

4987 STUDY OF COPPER PRECIPITATION BEHAVIOR IN SILICON SINGLE CRYSTALS. G.H.Schwuttke.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 163-7 (Feb., 1961).
The precipitation behaviour of copper in silicon single crystals containing different amounts of oxygen was investigated within the temperature range 900°-1300° C. Precipitation which occurs during the cooling period on structural defects and at random sites throughout the bulk crystal was detected by infrared transmission microscopy. The shape and crystallographic relationship of the precipitate as related to the silicon matrix was determined. The reliability of the method of copper decoration for the determination of low dislocation densities in the presence of oxygen was investigated by comparing copper decoration pictures with X-ray diffraction photomicrographs.

4988 REPLY TO DISCUSSION "ABSOLUTE GRAIN BOUNDARY ENERGIES IN COPPER". M.A.Gjostein.
Acta metallurgica (Internat.), Vol. 8, No. 4, 263-5 (April, 1960).
This is a reply to Fleischer (Abstr. 17949 of 1960) who suggested that the results of Gjostein and Rhines [Acta metallurgica (Internat.), Vol. 7, 319 (1959)] on the energies of tilt boundaries in copper would agree with the Shockley—Read equation at large angles if a suitable temperature variation of the elastic modulus is assumed and if the effect of a small twist component in the boundary is allowed for. Both these criticisms are refuted by the present author, who shows that the temperature variation of the elastic constants used by Fleischer is unrealistically large and results in erroneous conclusions and that Fleischer's analysis of the effect of a small twist component is incorrect leading to a magnification of the effect of this component on the shape of Shockley—Read curve. R.Bullough

# Diffusion

4989 DIFFUSION OF ANTIMONY IN GERMANIUM ALLOYED WITH ALUMINIUM. I.P.Akimchenko and L.S.Milevskii.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2109-16 (Sept., 1960). In Russian.
For abstract, see Abstr. 988 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1891-6 (March, 1961)].

4990 DIFFUSION OF HYDROGEN THROUGH PALLADIUM. R.C.Hurlbert and J.O.Konecny.
J. chem. Phys. (USA), Vol. 34, No. 2, 655-8 (Feb., 1961).

Diffusion rates F ($cm^3$ STP/$cm^2$ min) of hydrogen from the upstream pressure P (atm) into vacuum through a palladium sheet of thickness L (microns) are represented by

$$\log F = 3.70 + 0.68 \log P - 623/T - \log L,$$

except for very thin membranes. Explanations are suggested for the wide discordance of earlier results in the study of the diffusion of hydrogen through palladium.

4991 DIFFUSION IN COMPOUND SEMICONDUCTORS. B.Goldstein.
Phys. Rev. (USA), Vol. 121, No. 5, 1305-11 (March 1, 1961).

Self-diffusion in single crystal InP and GaAs was measured, together with the diffusion of the acceptors Cd and Zn and the donors S and Se in GaAs. Radioactive isotopes of these elements were used as tracers. The diffusions of In and P in InP are characterized by activation energies of 3.85 and 5.65 eV, respectively; those for Ga and As in GaAs are characterized by activation energies of 5.60 and 10.2 eV, respectively. The marked differences in both activation energies and diffusion rates of the constituent atoms in these materials indicate that the basic mechanism of the self-diffusion is one of migration within a specific sublattice. The impurity diffusion measurements in GaAs suggest that the concept of sublattice diffusion be extended to include impurity diffusion when the impurities enter the lattice substitutionally. The activation energy of the diffusion of both Cd and Zn in GaAs is about 2.5 eV, while that of the diffusion of both S and Se in GaAs is about 4.1 eV. Experimental details of interest include the observation of GaAs compound formation when GaAs is heated in S vapour and the formation of glassy layers on the surface of GaAs due to Se.

4992 INVESTIGATION OF THE TEMPERATURE DEPENDENCE OF ELECTRICAL TRANSPORT IN ALLOYS BASED ON REFRACTORY METALS.
M.D.Smolin and I.N.Frantsevich.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 81-3 (Jan. 1, 1961).
In Russian.

Wire specimens of 25 at.% Mo–W and 25 at.% W–Mo alloys were heated at 1500-2500°C in a constant electric field and the resultant change in the concentration of both components along the specimens was determined by the radioactive tracer technique. In every case movement of the Mo and W ions towards the anodic and cathode ends of the wire, respectively was observed. The effective charge, z*, of the ions was calculated from the experimental data, and it was established that $z^* \sim 1/T$. [English translation in: Soviet Physics – Doklady (USA)]. M.H.Sloboda

4993 ISOTOPE EFFECT IN INTERMETALLIC DIFFUSION. J.G.Mullen.
Phys. Rev. (USA), Vol. 121, No. 6, 1649-58 (March 15, 1961).

Ten measurements of the isotope effect for diffusion of $Fe^{55}$ and $Fe^{59}$ in pure single crystals of silver and copper were made over approximately a 300 deg C temperature interval below the melting point. The measured isotope effect was found to be about $\frac{2}{3}$, significantly less than the value of unity expected from conventional reaction rate theory. It is shown from Vineyard's extension of reaction rate theory that the measured isotope effect is to a good approximation a product of the Bardeen-Herring correlation factor and the fraction of the total translational kinetic energy associated with the diffusing tracer in a tracer-vacancy exchange. It is shown that the ring, interstitialcy, crowdion, and relaxation mechanisms are not responsible for diffusion in the systems studied. The three-frequency theory of correlation for vacancy diffusion in f.c.c. lattices is extended to show that the relative frequency factors are completely specified by a knowledge of the correlation factor and the diffusion coefficients. An expression for the difference in the Arrhenius Q and the activation energy due to the temperature dependence of the correlation factor is derived. This theory is shown to be inconsistent with the observed isotope effect if many-body effects are neglected. It is shown that a "long-range" repulsive interaction between the vacancy and impurity would be necessary if the measured isotope effect is to be explained purely in terms of correlation.

DIFFUSION IN METALS UNDERGOING PLASTIC DEFORMATION. See Abstr. 3980-3

# Colour Centres

4994 THE BLUE COLOUR OF APATITES. V.M.Vinokurov and M.M.Zaripov.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 61-2 (Jan. 1, 1961). In Russian.

The spectrum of electron spin resonance (e.s.r.) of apatite monocrystals was analysed. It appeared that the blue colour is due to F-type colour centres, while the colourless and pinkish Mn apatites show an effect due to $Mn^{2+}$, this ion being linked to the surrounding matter mostly by ionic bonds. The blue apatites were found to contain much less $Mn^{2+}$ than the colourless ones. In addition to faint lines due to $Mn^{2+}$, the e.s.r. spectrum of the blue apatites contained a strong line with six satellites. When the blue apatites were heated to ~500°C they became colourless and the strong line with satellites disappeared; irradiation with $\beta$- and $\gamma$-rays restored the bluish tinge and the line with satellites. [English translation in: Soviet Physics–Doklady (USA)]. F.Lachman

4995 PRESSURE INDUCED COLOR CENTERS IN $CaF_2$ AND $BaF_2$. S.Minomura and H.G.Drickamer.
J. chem. Phys. (USA), Vol. 34, No. 2, 670-1 (Feb., 1961).

The effect of pressure to 52 800 atm was studied on X-irradiated $CaF_2$ and $BaF_2$. The three bands discovered by Smakula are little affected by pressure or bleaching. There are two new bands induced by pressure, which are greatly enhanced by any change in pressure. These bands show a marked blue shift with increasing pressure. Each can be bleached by light of its own frequency, and restored by reapplication of pressure. It is suggested that the pressure-induced bands are due to electrons associated with pressure-induced lattice defects, while the bands discovered by Smakula are associated with colloidal deposits or impurities.

4996 CALCULATOR FOR SOLVING ELECTRON IRRADIATION PROBLEMS. E.H.Cornish.
J. sci. Instrum. (GB), Vol. 38, No. 3, 82-5 (March, 1961).

A discussion is given of the factors involved in the accurate radiation dosimetry of objects bombarded with initially monoenergetic electrons. It is necessary to match the incident electron energy with superficial density in the case of a parallel-sided target in order to attain uniform dose distribution. A preferable procedure is to employ the maximum electron energy available and to use a beam filter of suitable thickness, interposed between the electron source and (in contact with) the target. Such a combination minimizes the maximum overdose given. Another concept described is that of average dose factor, which arises because of the asymmetry of the normal ionization curve. Details of a simply made instrument are given, enabling electron dosimetry calculations to be made by a mechanical analogue of the normal ionization curve. It shows values for optimum electron energy, filter thickness required, and also for average dose factor once the superficial density of the target is known.

4997 ROLE OF M, R AND F' COLOUR CENTRES IN INFRARED FLUORESCENCE OF F-CENTRES IN ALKALI-HALIDE CRYSTALS. I.I.Ezhik and S.T.Shovlo.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 772-4 (Dec., 1960).
In Russian.

Describes a study of infrared fluorescence (1-1.5 $\mu$) of F-centres in NaCl, KCl and KBr at 100-300°K. The results are interpreted by means of an energy-band scheme with F-centres represented by a system of ground and excited levels and with F', M and R centres represented as electron acceptor levels in the forbidden band. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

4998 ELECTRONIC PROCESSES IN COLOURED NaCl CRYSTALS WITH CADMIUM. A.Bohun, J.Dolejší, M.Kaderka, J.Kantůrek, I.Kunzlová, M.Lébl and J.Trnka.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 214-24. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). NaCl crystals doped with Cd were grown from the melt. Most of the measurements were made with crystals containing $10^{-4}$ Cd/Na. Colour centres were introduced by radiation or by heating in an atmosphere of Na vapour. The variation of absorption, exoemission and photoemission with temperature was compared with thermoluminescence over the range 300-700°K, for doped and undoped crystals. No absorption due to $Cd^{++}$ was detected in the

isible or near ultraviolet regions. Absorption at 2500 A and 2900 A as ascribed to $Cd^+$ and un-ionized Cd, respectively. The F-centres n NaCl:Cd are ionized at about 450° C, compared with 550° C for ure NaCl. J.Franks

4999 OPTICAL TRANSITIONS IN A U-CENTRE IN A NaCl CRYSTAL. A.A.Kiselev and I.V.Abarenkov.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 765-71 (Dec., 1960). In Russian.

Discusses a U-centre in NaCl which can be represented as a negative hydrogen ion, localized at an anion vacancy. The polarizable-lattice approximation is used to calculate energies of transitions representing U-band absorption and emission and the half-width of the U-absorption band at 192 mμ. The results agree satisfactorily with experiment. [English translation in: Optics and Spectrosc. (USA)]. A.Tybulewicz

# ELECTRICAL PROPERTIES OF SOLIDS

*(Superconductivity is included under Low-Temperature Physics)*

5000 THE ELECTRICAL RESISTANCE OF AN ANTIFERROMAGNETIC. A.A.Berdyshev and I.N.Vlasov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 628-9 (Oct., 1960). In Russian.

Shows that the contribution to the electrical resistance of an antiferromagnetic due to interaction of conduction electrons with spin waves is proportional to $T^5$ (T is the absolute temperature) at low temperatures; this contrasts with the case of a ferromagnetic, where this contribution is proportional to $T^2$. A.Tybulewicz

5001 THE CHANGE IN ELECTRICAL RESISTIVITY OF SEVERAL METALS UP TO A PRESSURE OF 200 000 kg/cm$^2$.
L.F.Vereshchagin, A.A.Semerchan, N.N.Kusin and S.V.Popova.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 2, 320-1 (Jan. 11, 1961). In Russian.

The change of electrical resistance with pressure was measured for antimony, arsenic and calcium. The pressures were calibrated by using known transition pressures for other metals and a linear extrapolation beyond $1.25 \times 10^5$ kg/cm$^2$. Antimony showed a jump increase in resistivity at $1.3 \times 10^5$ kg/cm$^2$ ± 5%. Arsenic and calcium showed no phase changes; the resistivity decreasing with pressure for arsenic and increasing for calcium. [English translation in: Soviet Physics-Doklady (USA)]. M.G.Priestley

5002 ON THE RESIDUAL RESISTANCE OF BINARY ALLOYS. E.Verboven.
Phil. Mag. (GB) (Eighth Ser.), Vol. 5, 753-5 (July, 1960).

A theoretical analysis, with special reference to Ag—Pd alloys. An evaluation of the higher order terms of the Kubo conductivity formula (Abstr. 169 of 1958) accounts for most of the observed deviation from the Nordheim formula (Abstr. 3907 of 1931), leaving only a small extra resistance to be explained by inter-band scattering. H.Mykura

5003 ELECTRICAL RESISTIVITY OF LANTHANUM, PRASEODYMIUM, NEODYMIUM, AND SAMARIUM.
J.K.Alstad, R.V.Colvin, S.Legvold and F.H.Spedding.
Phys. Rev. (USA), Vol. 121, No. 6, 1637-9 (March 15, 1961).

The electrical resistivities of polycrystalline samples of La, Pr, Nd, and Sm are reported in the temperature range 1.3° to 300°K. La exhibits a superconducting transition at 5.8°K. The curve for Pr has slope changes at 61° and 95°K. The Nd curve shows small jumps at 5° and 20°K. Sm shows slope changes at 14° and 106°K.

5004 ELECTRICAL, THERMOELECTRIC AND MAGNETOELECTRIC PROPERTIES OF TRANSITION-METAL SILICIDES. V.S.Neshpor and G.V.Samsonov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 817-20 (Aug. 1, 1960). In Russian.

The electrical resistance, thermoelectric power and the Hall effect of silicides of Ti, V, Co, Zr, Ta, Ni, W, Mo, Cr, Re, Mn, Fe, Nb, La, Ce and Pr were studied. The transition metals could be divided into two groups. Silicides of the first group (Ti, Zr, V, Ta, W and Mo) had metallic conduction with a positive temperature coefficient of electrical resistance and low thermoelectric power. Silicides of the second group (Cr, Fe, Re and Mn) had semiconducting properties: a negative temperature coefficient of electrical resistance and high thermoelectric powers. La, Ce and Pr silicides had metallic conduction. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 790-3 (Jan.-Feb., 1961)]. A.Tybulewicz

5005 ELECTRICAL PROPERTIES OF LANTHANUM HEXABORIDE.
Yu.B.Paderno, G.V.Samsonov and V.S.Fomenko.
Fiz Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 633-5 (Oct., 1960). In Russian.

The electrical resistivity of lanthanum hexaboride rose with its porosity, but its thermoelectric power was practically independent of porosity. The temperature dependence (0-2000° C) of the resistivity showed that the compound had typical metallic conduction. A.Tybulewicz

HALL EFFECT IN SOLID MERCURY. See Abstr. 4356

5006 GALVANOMAGNETIC AND THERMOMAGNETIC EFFECTS IN ISOTROPIC MATERIALS.
A.C.Pipkin and R.S.Rivlin.
J. math. Phys. (USA), Vol. 1, No. 6, 542-6 (Nov.-Dec., 1960).

Invariant-theoretical considerations are employed to obtain constitutive equations for the current density vector, the heat flux vector, and the magnetic intensity field in isotropic materials (both holohedral and hemihedral) when an electric field, a magnetic induction field, and a temperature gradient are simultaneously present in the material. Certain of the interaction effects which are indicated by these constitutive equations are discussed.

## Semiconductors

5007 PROGRESS IN SEMICONDUCTORS. VOL. 4.
Edited by A.F.Gibson, F.A.Kröger and R.E.Burgess.
London: Heywood and Co. (1960) 291 + viii pp.

This volume contains a preface and eight review articles. Abstracts of the articles will appear in this or subsequent issues of Physics Abstracts.

5008 PROGRESS IN SEMICONDUCTORS. VOL. 5.
Edited by A.F.Gibson, F.A.Kröger and R.E.Burgess.
London: Heywood and Co. (1960) 316 + vii pp.

This volume contains a preface and seven articles. Abstracts of the articles will appear in this or subsequent issues of Physics Abstracts.

5009 THE MECHANISM OF THE ELECTRICAL CONDUCTIVITY OF FERRO- AND ANTIFERROMAGNETIC SEMICONDUCTORS. Ya.M.Ksendzov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2778-83 (Nov., 1960). In Russian.

An explanation is given of a set of basic experimental data relating the electrical conductivity to temperature in the case of ferro- and antiferromagnetic compounds of elements of group 3d, taking into account the effect of magnetic ordering. In the case of ferromagnetic ordering, a d-band is formed in all these compounds; the metallic or semiconducting character of the conductivity depends on the degree of filling of the d-shell of the transition elements and the symmetry of the crystal field. In antiferromagnetics, the wave-function of the d-electrons must be regarded as a localization on the ions (atoms); the conductivity is of the semiconducting kind. In the paramagnetic range, the d-bands are formed when the total angluar momentum J is small. When the J of the ion of the transition element is large, the d-band is formed in small volumes as a result of the fluctuations of the magnetic array, and the energy of activation of the electrical conductivity turns out to be connected with the formation of a conduction band. [English translation in: Soviet Physics—Solid State (USA)]. N.Davy

5010 IMPACT IONIZATION AND THE TUNNEL EFFECT IN SEMICONDUCTORS. B.M.Vul.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2961-71 (Nov., 1960). In Russian.

A brief survey of both effects in p–n junction is presented, with particular reference to Soviet contributions. The mechanism of the ionization breakdown according to Townsend is considered, supported by experimental evidence by Shotov (Abstr. 6988 of 1958) and the author (Abstr. 15937 of 1960). This yields values for the impact ionization coefficients for electrons and holes in Ge and Si in terms of constants and field strength. Theoretical support is provided by Keldȳsh (Abstr. 9958 of 1960) and Chuenkov (Abstr. 15910-11 of 1960). A brief treatment of impact effects in p-type Ge at very low temperatures is given, illustrated by a plot of current density versus field strength of 4.2°K. Tunnel diode physics are discussed in terms of Fermi levels. [English translation in: Soviet Physics – Solid State (USA)]. A.Landman

5011 A THEORY OF IMPURITY STATES IN SEMICONDUCTORS. V.L.Bonch-Bruevich.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 177-81 (1959). In Russian.

Considers non-Coulomb interactions of carriers with charged impurity centres and consequences of such interactions in impurity energy bands. A.Tybulewicz

5012 THE TEMPERATURE DEPENDENCE OF THE NON-EQUILIBRIUM CARRIER LIFETIME IN THE CASE OF RECOMBINATION ON MULTICHARGED CENTRES IN SEMICONDUCTORS. A.A.Grinberg.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 192-9 (1959). In Russian.

Considers special cases of the temperature dependence of the non-equilibrium carrier lifetime (e.g. triply charged centres, low temperatures, low densities of centres) and compares them with the case of recombination on doubly-charged centres. A.Tybulewicz

5013 THE POSSIBILITY OF USE OF INDIRECT TRANSITIONS TO OBTAIN NEGATIVE TEMPERATURE IN SEMICONDUCTORS. N.G.Basov, O.N.Krokhin and Yu.M.Popov.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 5(11), 1486-7 (Nov., 1960). In Russian.

In certain semiconductors, especially in germanium and silicon, the edge of the infrared absorption and emission band corresponds to "indirect transitions", i.e. processes in which emission and absorption of a photon is accompanied by emission or absorption of a phonon. If the carrier density is raised over its equilibrium value, the conditions under which a negative temperature (negative absorption) with respect to these indirect transitions can be attained in a semiconductor are described by $\omega_r/\omega_f < T_{eff}/T$, where $\omega_r$ and $\omega_f$ are, respectively, the frequencies of photon and phonon, T is the temperature of the specimen, and $T_{eff}$ denotes the effective temperature at which the conduction band levels become filled. [English translation in: Soviet Physics–JETP (USA), Vol. 12, No. 5, 1033 (May, 1961)]. M.H.Sloboda

5014 A PHOTOELECTRIC METHOD OF DETECTING INHOMOGENEITY WITH DEPTH OF SEMICONDUCTORS. É.I.Rashba and V.A.Romanov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2689-92 (Nov., 1960). In Russian.

A method of obtaining the variation of the carrier lifetime with depth, by measuring the variation with frequency of the effective lifetime, is described. Results are given for experiments on a p-type germanium crystal. Another method of obtaining the same quantity for a crystal in which the lifetime depends on the intensity of illumination is outlined. [English translation in: Soviet Physics–Solid State (USA)]. K.G.Major

DIFFUSION IN COMPOUND SEMICONDUCTORS.
See Abstr. 4991

UNIFORMITY OF CURRENT FLOW IN CYLINDRICAL SEMICONDUCTOR SPECIMENS USED FOR MEASUREMENTS.
See Abstr. 4551

# Semiconducting Materials

5015 EXTENDED CURVES OF THE SPACE CHARGE, ELECTRIC FIELD, AND FREE CARRIER CONCENTRATION AT THE SURFACE OF A SEMICONDUCTOR, AND CURVES OF THE ELECTROSTATIC POTENTIAL INSIDE A SEMICONDUCTOR. C.E.Young.
J. appl. Phys. (USA), Vol. 32, No. 3, 329-32 (March, 1961).

This article is an extension of work by Kingston and Neustadter (see Abstr. 7035 of 1955). They calculated the space charge, electric field, and change in free-carrier concentration for a semiconductor surface. Their results may be expressed as functions of the deviation for the Fermi energy from its intrinsic value in the bulk and at the surface. Curves calculated from their results may be used for any non-degenerate semiconductor at any temperature, provided that the donor and acceptor levels are completely ionized. However, these curves are extensively applicable only to germanium or semiconductors of similar energy gap. The extended curves presented in this article enable computations to be applied to materials of higher energy gap, such as silicon and gallium arsenide, over a wide resistivity range. Also, several curves of electrostatic potential inside a semiconductor have been computed, of which a few were presented previously by Dousmanis and Duncan (see Abstr. 1437 of 1959).

SURFACE STRUCTURES AND PROPERTIES OF DIAMOND-STRUCTURE SEMICONDUCTORS.
See Abstr. 4078

5016 THE ELECTRON DENSITY DISTRIBUTION IN GERMANIUM. N.N.Sirota and A.U.Sheleg.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 5, 1176-8 (Dec. 11, 1960). In Russian.

The atomic scattering factor f was measured on 5-8μ powder prepared from 60 ohm cm n-type material. The absolute values were determined from the attenuation through thicknesses from 50 to 200μ and by comparison with Si and NaCl. Figures show f versus $\sum_i h_i^2$ and ln f versus $\sum_i h_i^2$. The latter is linear for $\sum_i h_i^2 > 8$. The density distribution in the (110) plane is shown. The ionic radius determined by a density level of 1.5 el/A$^3$ is 0.5 A with 6 electrons outside. For 0.05 el/A$^3$ the radius is 2A. [English translation in: Soviet Physics–Doklady (USA)]. R.Berman

5017 RECOMBINATION OF EXCESS CARRIERS AT TWIN STRUCTURES IN GERMANIUM. J.P.McKelvey.
J. appl. Phys. (USA), Vol. 32, No. 3, 442-5 (March, 1961).

A study of recombination of excess charge carriers at twin structures in germanium is made. The continuity equation is solved for a thin (one-dimensional) slab with a twin boundary of arbitrary recombination velocity bisecting the slab and parallel to the large faces of the sample. The results of lifetime measurements made on samples cut to approximate this geometry may then be made to yield the twin boundary recombination velocity, provided that suitable assumptions about the recombination velocity at the outer surfaces of the sample are made. Upper limits to the twin boundary recombination velocity are inferred from experimental evidence and the case of a "double" or "second-order" twin boundary is investigated.

5018 EFFECT OF A CONSTANT ELECTRICAL FIELD ON GERMANIUM FAST SURFACE STATES. Y.Margoninski.
Phys. Rev. (USA), Vol. 121, No. 5, 1282-5 (March 1, 1961).

The experimental evidence regarding the effect of electric field on the fast states of germanium is, at present, contradictory: Litovchenko and Lyashenko (Abstr. 1639 of 1960) explained their experimental results by assuming the fields only affect the density of states but not their energy; this would support the current view on charge transfer through the semiconductor oxide layer. Rzhanov et al., on the other hand, reported field-induced changes in energy as well as density. To resolve this question, careful measurements of surface recombination velocity and surface conductivity were performed before and after application of d.c. fields of about $2 \times 10^5$ V cm$^{-1}$. Though the effect of the field on the surface state density was much smaller than that found by Litovchenko and Lyashenko, the experimental results indicated clearly that the energy and ratio of capture cross-sections were indeed unaffected by the field. It was also found that in wet ambients an a.c. field shifted the unperturbed surface potential by more than +5 kT.

5019 MEASUREMENT OF SHORT LIFETIMES OF NONEQUILIBRIUM CHARGE CARRIERS IN GERMANIUM. K.D.Glinchuk, E.G.Miselyuk and A.I.Skopenko.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 62-4 (March-April). In Russian.

It is shown that it is possible to measure short lifetimes ($\tau \sim < 0.5$ μsec) from the delay time of the collector current of a point-contact transistor operating in the saturation region. Data are presented which illustrate the applicability of the method of conductivity modulation for this purpose. [English translation in: Instrum. exper. Tech. (USA), No. 2, 245-8 (March-April, 1958; Publ. April, 1959)].

5020 RADIO-FREQUENCY CARRIER AND CAPACITIVE COUPLING PROCEDURES FOR RESISTIVITY AND LIFETIME MEASUREMENTS ON SILICON.
I.R.Weingarten and M.Rothberg.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 167-71 (Feb., 1961).

The measurements were made without direct ohmic contact to the samples. Even with contacts, the use of r.f. carrier to observe lifetime by photoconduction decay eliminates the need for insuring solid ohmic contacts as is required with a d.c. carrier. With low loss insulation between coupling capacitors and sample, an r.f. bridge will measure separately both the sample resistance between the coupling capacitors and the value of this coupling capacitance.

5021 MAGNETOELECTRIC EFFECTS IN $Bi_2Te_3$ IN THE CASE OF ANISOTROPIC SCATTERING OF CARRIERS.
L.Ya.Korenblit.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 12, 3083-91 (Dec., 1960). In Russian.

Derives the collision term in the kinetic equation for scattering which can be described by a relaxation-time tensor with components independent of the direction of the electron wave-vector. Magneto-electric coefficients are calculated for $Bi_2Te_3$ with this type of scattering in weak fields. [English translation in: Soviet Physics—Solid State (USA)]. A.Tybulewicz

5022 SPACE-CHARGE CURRENTS IN GALLIUM ARSENIDE. J.W.Allen and R.J.Cherry.
Nature (GB), Vol. 189, 297-8 (Jan. 28, 1961).

Current—voltage curves for semi-insulating GaAs with tin contacts show at low voltages a region where Ohm's law is obeyed; at higher voltages the current is space-charge limited and is proportional to the square of the voltage. The concentration of unfilled traps is found to be near $10^{11}$cm$^{-3}$. C.Hilsum

5023 OBSERVATIONS OF ELECTRON—HOLE CURRENT PINCHING IN INDIUM ANTIMONIDE.
M.Glicksman and R.A.Powlus.
Phys. Rev. (USA), Vol. 121, No. 6, 1659-61 (March 15, 1961).

The temporal variation at high electric fields of the current and voltage in n-type InSb is examined. The observations show the behaviour characteristic of self-pinching of the electron—hole plasma current. There is good agreement with theory for the observed times for the pinching process as a function of current. The calculated sum of the average energies of the electron and holes in the plasma is 0.037 eV. Oscillations in the electric field of apparently different character are observed during the pinch, and when a longitudinal magnetic field is applied.

ELECTRICAL CONDUCTIVITY OF $MnO_2$. See Abstr. 5111

# Photoconductivity

5024 PHOTOCONDUCTIVITY OF CdS-TYPE PHOTOCONDUCTORS IN THE VICINITY OF THE ABSORPTION EDGE.
N.N.Winogradoff.
J. appl. Phys. (USA), Vol. 32, No. 3, 506-9 (March, 1961).

The marked drop in photoconductivity on the high-energy side of the absorption edge in high quantum-yield photoconductors cannot be explained satisfactorily in terms of the models based on the trapping of the free holes produced in band-to-band excitations. In the model described, the photocurrent is assumed to arise mainly through the excitation of electrons from discrete levels very close to the valence band. The trapped holes formed in this process are in an excited state and drop to a ground state further away from the valence band, where they are relatively stable against thermal ionization and give rise to high quantum yields. This model for the photoconductivity mechanism appears to explain a large variety of experimentally observed characteristics.

5025 PHOTOELECTRIC EFFECT IN Ag—As—S ALLOYS.
H.Kutlu and M.Öğder.
Bull. Tech. Univ. Istanbul (Turkey), Vol. 13, No. 1, 1-31 (1960).

Artificially prepared alloys obtained from $Ag_2S$ and $As_2S_3$ were found to contain small crystals of argentite, proustite and smithite. The magnitude of the photoelectric affect in such ternary alloys was found to depend on the inhomogeneity of the alloy. W.Bardsley

5026 A NEW NEGATIVE PHOTOCONDUCTIVITY EFFECT IN A MAGNETIC FIELD.
A.A.Grinberg, S.R.Novikov and S.M.Ryvkin.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 2, 329-31 (Jan. 11, 1961). In Russian.

The photoconductivity of p-and n-type germanium was observed to decrease when placed in a magnetic field. This decrease is explained in terms of modified trajectories of current carriers in the field. A formula for the fractional change in conductivity is given in terms of the Hall angles and a function proportional to the level of illumination. Graphs are plotted for various ratios of the increase in electron concentration to that of holes. [English translation in: Soviet Physics—Doklady (USA)]. K.N.R.Taylor

5027 LOW-TEMPERATURE PHOTOCONDUCTIVITY OF ADDITIVELY COLORED KCl.
R.L.Wild and F.C.Brown.
Phys. Rev. (USA), Vol. 121, No. 5, 1296-1302 (March 1, 1961).

The transient photoconductivity of additively coloured crystals of KCl was investigated at temperatures down to 10°K. The spectral response reflects the structure in optical absorption in the ultra-violet reported by Lüty (1959). Quantum yields are found to be less than 1.0 at 10°K but are much higher in the region of the $L_1$ (3.6 eV) and $L_2$ (4.2 eV) bands than in the K-band on the high-energy side of the F-band. The beginning of electron collection or saturation effects was found in the case of thin, lightly coloured crystals which indicates that electron ranges were in the vicinity of $10^{-6}$ cm$^2$ V$^{-1}$ at 10°K. Shallow traps effective below 26°K were found in the crystals studied so far. These traps have a large product of concentration times cross-section and compete favourably with the F-centre at 10°K. They can be partly filled following illumination at low temperature with the result that enhanced photoresponse is produced in the red and near infrared.

5028 PHOTOELECTRIC HALL EFFECT IN KCl AT LOW TEMPERATURES. F.C.Brown and N.Inchauspé.
Phys. Rev. (USA), Vol. 121, No. 5, 1303-5 (March 1, 1961).

The Hall effect for carriers released by light was studied over a temperature range 4° to 114°K in additively coloured crystals of KCl containing various concentrations of F-centres. A negative Hall signal was observed corresponding to electrons released from F-centres by light absorbed in the high-energy side of the F-band. The Hall mobility rises steeply below 80°K due to freezing out of the optical modes of lattice vibration. A residual mobility near 4000 cm$^2$ V$^{-1}$ sec$^{-1}$ is found below 30°K in the crystals prepared so far.

5029 ANISOTROPY OF THE PHOTOMAGNETIC EFFECT IN CUBIC CRYSTALS. G.I.Kharus and I.M.Tsidil'kovskii.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 3, 341-5 (Sept., 1960). In Russian.

Calculations for n-type Ge (spherical energy surfaces are assumed) show that the angular dependence (anisotropy) of the photomagnetic effects in any magnetic field is correctly predicted by a phenomenological theory developed by the authors for cubic crystals. A.Tybulewicz

5030 THE ANISOTROPY OF THE EVEN PHOTOMAGNETIC EFFECT IN N-GERMANIUM AT LOW TEMPERATURES.
I.K.Kikoin and S.D.Lazarev.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 5(11), 1471-3 (Nov., 1960). In Russian.

The even photomagnetic effect (see Abstr. 1283 of 1957) was measured on single crystals (thin disks) of n—Ge at liquid—nitrogen temperatures. The quantity measured was the even photomagnetic e.m.f. $E_q$. In weak magnetic fields this e.m.f. nearly agrees with that predicted by the equation $E_q = LH^2 \sin^2\theta\cos 3\phi/3\sqrt{2}$, where L is a constant of the material, H the magnetic field strength, $\phi$ the azimuthal angle, and $\theta$ the angle between the magnetic field and the normal to the face of the disk. This normal was also the [111] direction of the crystal. Using strong magnetic fields (H > 6000 Oe)

the above law is no longer obeyed. $E_q$ has zero value when $\theta = 0$ and 180°, a minimum when $\theta = 90°$ and maxima when $\theta = 54°$ and 126°. No satisfactory theory of this anomalous behaviour has yet been given. [English translation in: Soviet Physics–JETP (USA), Vol. 12, No. 5, 1022 (May, 1961)]. N.Davy

5031 PHOTOCHEMICAL REACTIONS AND LIFETIME OF PHOTOCELLS. K.W.Böer and W.Borchardt.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 51-4. In German.

Intensive illumination of doped CdS single crystals produces effects similar to those at high temperatures and causes photochemical reactions which are of a similar nature for all crystals. A study of such effects led to processes for making more stable CdS photoconductive cells. C.A.Hogarth

# Thermoelectric Properties

5032 THEORETICAL BOUND ON THE THERMOELECTRIC FIGURE OF MERIT FROM IRREVERSIBLE THERMODYNAMICS. H.Littman and B.Davidson.
J. appl. Phys. (USA), Vol. 32, No. 2, 217-19 (Feb., 1961).

The principles of irreversible thermodynamics are used with an idealized model to independently derive Ioffe's dimensionless "figure of merit", $T\alpha^2\sigma/(\kappa)J_2 = 0$, and a theoretical upper bound of infinity.

5033 THERMOELECTRIC BEHAVIOR OF P–N JUNCTIONS. M.Cutler.
J. appl. Phys. (USA), Vol. 32, No. 2, 222-7 (Feb., 1961).

Equations are derived, on the basis of an emission model, for the flow of carriers and electronic heat which occurs when a temperature drop as well as an applied potential exists across a p–n junction. The application of the equations is discussed for small-signal situations, where the Onsager relation is obeyed, as well as for large-signal situations. In particular, the efficiency of p–n junctions for thermoelectric conversion is compared with that of homogeneous semiconductors and thermionic diodes.

5034 THERMOELECTRIC PROPERTIES OF SOLID SOLUTIONS OF CHROMIUM, VANADIUM AND TITANIUM WITH NICKEL.
M.V.Vedernikov and N.V.Kolomoets.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2713-27 (Nov., 1960). In Russian.

For small concentrations c of the solvent the change in the electrical resistance at room temperature is $\Delta\rho = ca + cbN^2$, where N is the difference between the effective valencies of the solvent and the solute. The first term is ascribed to an increase in s–d transitions. Curves are given of the resistance change as a function of concentration and temperature and of the absolute thermoelectric power. The latter is also calculated for Ni–Cr solution at 45°C and the agreement with experiment is good. The maximum occurs for $c = 0.11$, while $\epsilon_0 - \mu = 0$ for $c = 0.13$ ($\epsilon_0$ is the distance between the upper edge of the d-band and the bottom of the s-band; $\mu$ is the Fermi level). It seems justifiable to neglect any distortion of the Fermi surface. [English translation in: Soviet Physics–Solid State (USA)]. R.Berman

5035 EFFECT OF PRESSURE ON E.M.F. OF THERMOCOUPLES. F.P.Bundy.
J. appl. Phys. (USA), Vol. 32, No. 3, 483-8 (March, 1961).

"Pressure" thermal e.m.f.'s have been measured for constantan, Pt, Ni, alumel, Pt–10% Rh, Cu, chromel, and Ni–18% Mo for a ΔT of 100°C over a pressure range 0 to 72 kbar. Corrections due to pressure for common thermocouples made of pairs of these metals have been deduced. A number of thermocouple pairs have been compared at temperatures up to 1200°C and pressures up to 58 kbar. Below 200 to 300° the deviations between them agree quite well with the absolute data on single metals taken at ΔT of 100°C. At higher temperatures the deviations diminish and generally reverse. It appears that the deviation δT of the readings of two thermocouples at a given pressure follow roughly the relationship $\delta T = A(P)\Delta T + B(P)\Delta T^2$, where ΔT is the temperature interval in the pressurized zone, A(P) and B(P) are functions of pressure (roughly linear), and B(P) is generally opposite in sign to A(P) and is large enough to dominate the A(P) term at higher ΔT's.

# Dielectric Properties

5036 THE ANOMALOUS BEHAVIOUR OF V.H.F. PERMITTIVITY OF ANTIFERROMAGNETIC SEMICONDUCTORS AT THE NÉEL TEMPERATURE.
A.A.Samokhvalov, I.G Fakidov and E.I.Kopytov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 538-42 (Oct., 1960). In Russian.

On transition to the paramagnetic state at the Néel temperature (33-37°C), the 9500 Mc/s permittivity of $Cr_2O_3$ increased discontinuously by 3-4%. Dispersion of the permittivity between 100 and $10^8$ c/s is also discussed. A.Tybulewicz

5037 VALENCE VIBRATIONS OF HYDROXYL IN FERROELECTRIC CRYSTALS OF $KH_2PO_4$ AND $KD_2PO_4$.
A.N.Lazarev and A.S.Zaitseva.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 12, 3026-8 (Dec., 1960). In Russian.

Absorption spectra of $KH_2PO_4$ and $KD_2PO_4$ were determined and are discussed in relation to the tunnel effect of the proton and hydrogen bonding in these materials. [English translation in: Soviet Physics–Solid State (USA)]. R.F.S.Hearmon

5038 FERROELECTRIC PROPERTIES OF THE SYSTEM $(NH_2CH_2COOH)_3.H_2(SO_4, PO_3F)$.
T.G.Dunne and M.L.Wang.
J. Electrochem. Soc. (USA), Vol. 108, No. 1, 111-12 (Jan., 1961).

5039 ORDER–DISORDER MODEL THEORY FOR THE FERROELECTRIC EFFECT IN THE DIHYDROGEN PHOSPHATES. M.E.Senko.
Phys. Rev. (USA), Vol. 121, No. 6, 1599-1604 (March 15, 1961).

A term in polarization energy is added to the Slater–Takagi model of ferroelectricity in $KH_2PO_4$. This free-energy function relates the shift in Curie point temperature due to deuteration of the compound with the measured change in saturation spontaneous polarization. The dielectric constant $\epsilon_c$ obtained by numerical differentiation of the free-energy function has sharp maximum at the Curie temperature. With a change of parameters, the model also reproduces some of the details of antiferroelectric behaviour.

5040 THE SOLUTION OF THE PROBLEM OF THE THERMAL BREAKDOWN OF NON-UNIFORM DIELECTRICS.
S.N.Koikov and A.N.Tsikin.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 12, 2989-97 (Dec., 1960). In Russian.

Treats the one-dimensional problem of a plane sheet of dielectric in which the electrical resistivity is a function of temperature and coordinates. Formulae are derived for the breakdown voltage for two forms of the dependence of the resistivity on distance along the sheet. These differ from the value for the uniform case in the function describing the conditions of cooling at the two end planes. Graphs are given of this function for various values of the relevant parameters. [English translation in: Soviet Physics–Solid State (USA)]. R.Berman

5041 A METHOD FOR THE DYNAMIC DETERMINATION OF THE ELASTIC, DIELECTRIC, AND PIEZOELECTRIC CONSTANTS OF QUARTZ. S.A.Basri.
Nat. Bur. Stand. (USA), Monogr. 9, 1-22 (1960).

Several dynamic determinations were made of the constants of quartz. Most of these determinations do not take into account the piezoelectric effect; those that do, suffer from certain deficiencies which are discussed in this paper. Taking into account the piezoelectric effect, expressions for the frequency of longitudinal vibration of rectangular bars and thickness shear vibration of infinite plates are derived and applied to the determination of the constants of quartz. On the basis of present theoretical knowledge, it is suggested that the best procedure is to measure the frequency of vibration of 2 particular cuts for rectangular bars, and 7 cuts for plates, and to measure the capacitance at zero frequency of a rectangular bar. These 10 measurements provide the data for determining the 6 elastic, 2 dielectric, and 2 piezoelectric constants of quartz uniquely. For accurate measurements, it will first be necessary to determine the linear coefficients of expansion of quartz to higher accuracy than is available at present.

5042 COMMENT ON MONOGRAPH BY S.A.BASRI. W.G.Cady.
J. Acoust. Soc. Amer., Vol. 33, No. 2, 249 (Feb., 1961).
Refers to apparent discrepancies occurring in the treatment of the theory of longitudinal thickness vibrations in a plate of infinite area, between the results of Basri (see preceding abstract) and those of Cady [Piezoelectricity. W.G.Cady. New York: McGraw—Hill (1946)].

PIEZOELECTRIC PROBE FOR PLASMA RESEARCH. See Abstr. 4615

5043 OBSERVATIONS ON AN ELECTRICAL EFFECT OBTAINED DURING DEFORMATION OF SODIUM CHLORIDE CRYSTALS. G.Remaut and J.Vennik.
Phil. Mag. (GB), Vol. 6, 1-8 (Jan., 1961).
An electrical signal obtained during the plastic deformation of sodium chloride crystals is described. This effect is attributed to the movement of charged dislocations. During a first series of experiments the specimens were submitted to a cyclic deformation. The magnitude of the electrical effect was measured as a function of the amplitude of deformation. The influence of annealing was also investigated. In a second series of experiments the crystals were deformed by a series of stress pulses. A tentative explanation for the shape of the obtained signal is given.

# OPTICAL PROPERTIES OF SOLIDS

*(Including X-ray Spectra)*

5044 OPTICAL ACTIVITY IN TELLURIUM. K.C.Nomura.
Phys. Rev. Letters (USA), Vol. 5, No. 11, 500-1 (Dec. 1, 1960).
Elementary tellurium, having a symmetry which classifies it as enantiomorphous, was examined for optical rotatory power. The effect was found to be large in both left- and right-handed single crystals, yielding a value for the difference in refractive indices of the ordinary and extraordinary rays in the direction of the optic axis of $\pm 1.58 \times 10^{-3}$ at 5 $\mu$ wavelength. Deviations from normal dispersion were observed for wave numbers greater than $0.20 \times 10^4$ $cm^{-1}$, consistent with other measurements of refractive index.
I.Cooke

5045 OPTICAL FARADAY EFFECT IN GERMANIUM. B.Hartmann and B.Kleman.
Ark. Fys. (Sweden), Vol. 18, Paper 6, 75-82 (1960).
The Faraday rotation in doped and intrinsic single-crystal germanium was studied in the wavelength region 1.5-5.5 $\mu$. The effect in n-type germanium, with carrier concentrations in the range $6 \times 10^{16}$-$2 \times 10^{18}$ $cm^{-3}$, is shown to consist of two essentially independent contributions, due to bound and free electrons. A value of the effective mass of conduction electrons was calculated from the free carrier rotation. The Faraday rotation due to bound electrons takes on very large values for wavelengths shorter than 1.6 $\mu$ and has an opposite sense to the rotation at longer wavelengths. In p-type germanium of impurity concentrations as high as $3 \times 10^{17}$ $cm^{-3}$, no rotation was observed in the free carrier range.

5046 ABSORPTION AND PHOTOCHEMISTRY OF AgCl CRYSTALS CONTAINING DIVALENT CATIONS AND ANIONS. A.Scholz.
Ann. Phys. (Germany), Vol. 7, No. 3-4, 179-88 (1961). In German.
The optical absorption bands at $-185^\circ$C of AgCl crystals containing divalent cations ($Cd^{++}$, $Pb^{++}$, $Ca^{++}$, $Cu^{++}$), in addition to divalent anions, are generally displaced by 0.05-0.15 eV, compared with the bands of AgCl containing only $Ag_2S$ or $Ag_2Se$. The mixed crystals are almost insensitive below $-150^\circ$C: photochemical reaction occurs above about $-130^\circ$C. This behaviour is due to a decrease in the concentration of isolated and associated interstitial silver ions, caused by the addition of divalent cations. J.Franks

OPTICAL ABSORPTION OF NaCl AND KCl WITH Pb IMPURITY. See Abstr. 4983

CLOUDING OF PRESSINGS OF IONIC CRYSTAL POWDERS. See Abstr. 4024

5047 CRYSTAL SPECTRA OF METAL COORDINATION COMPOUNDS. III. NICKEL COMPLEXES WITH SALICYLALDEHYDE AND ITS IMINES. J.Ferguson.
J. chem. Phys. (USA), Vol. 34, No. 2, 611-15 (Feb., 1961).
For Pt II, see Abstr. 4414 of 1960. Polarized single crystal absorption spectra are reported for three nickel complexes: bis-N-methylsalicylaldiminato-nickel (II), bis-salicylaldiminato-nickel (II) and diaquo-bis-salicylaldehydato-nickel (II). The analysis of the bands of an orthorhombic form of bis-N-methyl-salicylaldiminato-nickel (II) (described for the first time) results in the assignment of the two visible absorption bands to $^1A_g \rightarrow {}^1B_{1g}$ and $^1A_g \rightarrow {}^1B_{3g}$, respectively. This assignment is discussed in relation to the simple crystal field model and a possible refinement of the model has been suggested. The analysis of the band observed with bis-salicyl-aldiminato-nickel (II) is consistent with the assignment of those in bis-N-methylsalicylaldiminato-nickel (II). The analysis of the visible absorption band of diaquo-bis-salicylaldehydato-nickel (II) shows that the theoretical assignment is incorrect although an unambiguous assignment cannot be made from the crystal spectrum.

5048 INFRARED ABSORPTION AND STRUCTURE OF THE HOLE BAND OF TELLURIUM.
V.M.Korsunskii and M.P.Lisitsa.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 7, 1619-23 (July, 1960). In Russian.
Measurements of the optical reflection and transmission spectra of tellurium monocrystals in the range 500-3000 $cm^{-1}$ gave a forbidden energy gap of 0.3-0.4 eV. The structure of an optical absorption band at 11 $\mu$ due to holes indicated that the energy surface of the hole energy band consists of two ellipsoids along the C axis of tellurium. [English translation in: Soviet Physics—Solid State (USA)].
A.Tybulewicz

5049 INFRARED ABSORPTION OF CUPROUS OXIDE ($Cu_2O$). H.Fickelscher and W.Zukale.
Naturwissenschaften (Germany), Vol. 48, No. 1, 24 (1961). In German.
Transmission measurements on polycrystalline layers indicate a number of absorption maxima in the range $\lambda$ = 8-24 $\mu$. There is a small $\lambda$ shift with changing temperature T, but the total intensity of the 8.9 $\mu$ band is independent of T (T = 90°-390° K).
G.F.Lothian

5050 INFRARED ABSORPTION OF AMORPHOUS SELENIUM WITH ADDED ARSENIC. W.Kamprath.
Naturwissenschaften (Germany), Vol. 48, No. 2, 42 (1961). In German.
A strong band appears at 12.6 $\mu$, whose intensity is proportional to the concentration of As up to 5%. Less than 0.1% As may be detected. It is attributed to a Se—As vibration. G.F.Lothian

5051 A QUANTITATIVE STUDY OF THE ABSORPTION SPECTRUM OF CUPROUS OXIDE. I.S.Gorban'.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 759-64 (Dec., 1960). In Russian.
The absorption spectra of $Cu_2O$ monocrystals and polycrystals were studied in the visible region, mainly at -180° C. The two hydrogen-like series of bands at the fundamental absorption edge were due to absorption by the lattice and not by impurities. The fundamental edge structure was explained in terms of transitions between states of the same parity. [English translation in: Optics and Spectrosc. (USA)].
A.Tybulewicz

5052 THE TEMPERATURE DEPENDENCE OF THE RAMAN BAND INTENSITIES IN CRYSTALLINE AND VITREOUS SOLIDS. I. AN EXPERIMENTAL STUDY IN THE STOKES REGION OF THE SPECTRUM. Ya.S.Bobovich and T.P.Tulub.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 747-53 (Dec., 1960). In Russian.
The temperature dependence of the Raman band intensities in the Stokes region was obtained for crystalline quartz, Iceland spar, fluorite, corundum, barytes, fused silica, glass, polymethylmethacrylate and polystyrene. The results are explained in terms of internal fields, using the refractive index and permittivity of the medium. [English translation in: Optics and Spectrosc. (USA)].
A.Tybulewicz

# Luminescence

5053 SOME CHARACTERISTICS OF THE POLARIZATION OF THE FLUORESCENCE OF PORPHYRINS.
A.N.Sevchenko, G.P.Gurinovich and K.N.Solov'ev.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 3, 564-7 (July 21, 1960). In Russian.

The absorption and luminescence spectra of porphyrin and pheophitin were investigated, along with the degree of polarization in the long-wavelength emission. In addition the polarization spectra for the first and second bands in the luminescence of these materials were obtained. The results are briefly considered using the Franck-Condon principle, by expressing the matrix element of the transition in the form of a series. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 808-11 (Jan.-Feb., 1961)].
K.N.R.Taylor

5054 BEHAVIOR OF EXCITED ELECTRONS AND HOLES IN ZINC SULFIDE PHOSPHORS.
S.Shionoya, H.P.Kallmann and B.Kramer.
Phys. Rev. (USA), Vol. 121, No. 6, 1607-19 (March 15, 1961).

The luminescent properties of silver and copper activated ZnS phosphors were investigated at room and liquid air temperatures using u.v., blue light, and $\beta$-ray excitation. In many cases it was found that the deficiency area was considerably smaller than the glow curve area, especially for $\beta$-ray excitation of ZnS:Cu. This is explained by the hole production causing quenching during $\beta$-ray excitation, while during the glow curve the smaller amount of holes produced causes a much smaller amount of quenching. However, even with blue light where excitation does not directly produce holes, the deficiency area is smaller than the glow curve area. The effects of infrared radiation on the fluorescence, phophorescence, and glow curve was investigated, and the quenching and stimulation at room and liquid air temperature reported. For ZnS:Cu the long wavelength infrared band (~12 000 A) produces quenching at room temperature but only stimulation at low temperature. A determination of trap density from the glow curves shows $\sim 10^{17}/cm^3$ for ZnS:Cu and $\sim 10^{16}/cm^3$ for ZnS:Ag at liquid air temperatures. Finally, a theoretical discussion of the possible transition mechanisms giving rise to these effects is given.

5055 VISIBLE LUMINESCENCE OF RARE-EARTH YTTRIUM GALLIUM GARNETS.
S.P.Keller and G.D.Pettit.
Phys. Rev. (USA), Vol. 121, No. 6, 1639-48 (March 15, 1961).

Yttrium gallium garnet ($Y_3Ga_5O_{12}$) was prepared with small percentages of different rare earths substituted for yttrium. Garnets activated with Pr, Sm, Eu, Tb, Dy, Ho, Er, and Tm are all luminescent. The emission and excitation spectra of the samples were measured at 77°K. The data are analysed in terms of the atomic energy levels of the impurity ions and the effects of crystalline field and of phonon interactions. Wherever possible, comments are made about whether the crystal field can be treated as possessing cubic or lower symmetry.

INFRARED FLUORESCENCE OF F-CENTRES IN ALKALI-HALIDE CRYSTALS. See Abstr. 4997

5056 EMISSION OF LIGHT FROM CRYSTAL PHOSPHORS STIMULATED BY ULTRASOUND AFTER IRRADIATION WITH ULTRAVIOLET LIGHT AND $\beta$-RAYS. K.Friedrich.
Ann. Phys. (Germany), Vol. 7, No. 3-4, 201-9 (1961). In German.

The ultrasound (800 kc/s) causes a very rapid increase in the phosphorescence of ZnS:Cu to a peak followed by rapid decay (Ausleuchtung). The dependence of the total light emission on the time and density of prior irradiation agrees with a theory based on the transfer of trapped electrons to the conduction band. The light output is proportional to the dose at low excitation density. For a $Ba_3Br_4F_2$ phosphor under $\beta$-rays from $Sr^{90}$, similar results were obtained at high but not at low excitation density. S.T.Henderson

5057 THE DIRECTIONAL DEPENDENCE OF THE SCINTILLATION LIGHT YIELD OF THIN ANTHRACENE AND STILBENE CRYSTALS IN THE CASE OF $\alpha$-RAY BOMBARDMENT.
P.H.Heckmann, H.Hansen and A.Flammersfield.
Z. Phys. (Germany), Vol. 162, No. 1, 84-92 (1961). In German.

A strong dependence of the light yield on the direction of incidence with respect to the crystal axes is found, confirming the results of previous measurements with thick anthracene crystals. For anthracene, the maximum light yield occurs for $\alpha$-particles incident approximately parallel to the c' axis. With stilbene, a minimum of the light output is found in the c' direction. For thin anthracene crystals, the direction of maximum light output depends slightly on the crystal thickness.

5058 PRINCIPAL PEAKS OF ELECTROLUMINESCENT BRIGHTNESS WAVES. A.N.Georgobiani and M.V.Fok.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 775-81 (Dec., 1960). In Russian.

A study of the form of brightness waves shows that at high applied voltages, liberation of electrons is governed mainly by electric fields. At low temperatures electrons are liberated by collision ionization and at high temperatures they are freed by tunnelling through potential barriers. From the electric field intensities at which complete liberation of electrons occurred the optical phonon energies and the energy depths of local levels were found for ZnS. These quantities were in good agreement with the optical phonon energies deduced from the vibrational structure of the "edge" luminescence spectrum and with the donor level depths found from the equilibrium density of free electrons in electroluminescent ZnS crystals. [English translation in: Optics and Spectrosc. (USA)].
A.Tybulewicz

5059 DEPENDENCE OF THE ELECTROPHOTOLUMINESCENCE OF A ZnCdS PHOSPHOR ON EXCITING WAVELENGTH AND FIELD PULSE WIDTH. H.Gutjahr and F.Matossi.
Z. Phys. (Germany), Vol. 162, No. 1, 105-113 (1961). In German.

Luminescence flashes in an excited ZnCdS : Ag phosphor occur when electric fields are switched on or off. Whether these flashes are positive or negative depends on the length of the field pulse, on the exciting wavelength, and on the polarity of the irradiated electrode. There is a critical duration of the field pulses for which no field-off flash appears. At another, but related, critical time, the flashes change sign under the application of a periodic field. These times change with the exciting wavelengths. The observations are interpreted as being controlled by the gradual filling of surface traps, which in its turn is influenced by the distribution of electron and hole concentrations produced by the incident radiation and the electric field. The critical time is approximately equal to the time needed for completely filling the surface traps.

5060 THERMOLUMINESCENCE IN DOLOMITE.
W.L.Medlin.
J. chem. Phys. (USA), Vol. 34, No. 2, 672-7 (Feb., 1961).

The thermoluminescent properties of dolomite were investigated by coprecipitating impurities which are likely to serve as activators with an otherwise pure sample. Only impurities which are likely to occur in natural samples were considered. The effects of cation and anion vacancies were also investigated and found to be unimportant. Divalent manganese was found to be the only activator of importance and its presence satisfactorily explains the important features of glow curves for natural samples. The results of luminescent efficiency as a function of activator concentration were determined. It was found that concentration quenching of the $Mn^{++}$ luminescence is characteristic of an isolated activator site. Quenching of the manganese luminescence by $Fe^{++}$, $Co^{++}$, and $Ni^{++}$ was also observed and quantitative results were compiled. All impurity ion concentrations were determined by colorimetric procedures. The presence of $Co^{++}$ or $Ni^{++}$ with $Mn^{++}$ produces high-temperature glow peaks which roughly coincide with similar peaks observed in natural samples. However, it appears more likely that the peaks in natural samples are due to lattice defects resulting from deformation pressures. Isothermal decay curves were measured for all of the glow peaks due to Mn++ and found to have the form predicted for a second-order decay process. However, the behaviour of one of the decay parameters as a function of activation time is different from the predicted behaviour. The trap depth energies and frequency factors associated with most of the glow peaks due to $Mn^{++}$ were also determined.

# MAGNETIC PROPERTIES OF SOLIDS

5061 DIAMAGNETIC SHIELDING OF NUCLEI IN METALS.
T.P.Das and E.H.Sondheimer.
Phil. Mag. (GB) (Eighth Ser.), Vol. 5, 529-31 (May, 1960).

It is shown that the conduction electrons in metals may produce an appreciable diamagnetic shift, in addition to the contribution to the paramagnetic shift through their spins. S.A.Ahern

DIAMAGNETISM OF MANY-FERMION SYSTEMS.
See Abstr. 4531

5062 SUSCEPTIBILITIES AND NEGATIVE KNIGHT SHIFTS OF INTERMETALLIC COMPOUNDS.
A.M.Clogston and V.Jaccarino.
Phys. Rev. (USA), Vol. 121, No. 5, 1357-62 (March 1, 1961).

Knight shift measurements have recently been made (Abstr. 19561 of 1960; 1277 of 1961) on a series of compounds having the β-wolfram structure $V_3X$, namely $V_3As$, $V_3Au$, $V_3Ga$, $V_3Ge$, $V_3Pt$, $V_3Sb$, $V_3Si$, and $V_3Sn$. More recently susceptibilities have been measured on some of these compounds. It is observed that (a) materials with a high superconducting transition temperature show temperature-dependent Knight shifts and susceptibilities, (b) the vanadium shifts $K_V$ are positive and decrease with decreasing temperature, and (c) the X-site shifts $K_X$ are negative and increase in magnitude with decreasing temperature. A simple model is offered which uses the exchange polarization mechanism to relate the sign and temperature dependence of $K_V$ and $K_X$ to the temperature-dependent susceptibility.

EXTREMUM PROBLEM IN THE VARIATION PRINCIPLE IN THE THEORY OF SUSCEPTIBILITY OR RELAXATION PHENOMENA.
See Abstr. 4287

5063 THE TEMPERATURE DEPENDENCE OF THE PARAMAGNETIC SUSCEPTIBILITY OF IRON–NICKEL ALLOYS. V.I.Chechernikov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 672-5 (Nov., 1960). In Russian.

Reports that the paramagnetic susceptibility of alloys with 38.8-89.6 at.% Ni obeys the Curie–Weiss law up to 1200°C. Reports also that the temperature-independent component of the susceptibility tends to zero with increase of the amount of Fe. A.Tybulewicz

NUCLEAR COOLING BY ISENTROPIC DEMAGNETIZATION OF COPPER NUCLEI. See Abstr. 4520

5064 COMPUTATION OF ORDER PARAMETERS IN AN ISING LATTICE BY THE MONTE CARLO METHOD.
J.R.Ehrman, L.D.Fosdick and D.C.Handscomb.
J. math. Phys. (USA), Vol. 1, No. 6, 547-58 (Nov-Dec., 1960).

The long-range and short-range order parameters are computed for the Ising lattice using a Monte Carlo sampling scheme. The square lattice, the simple cubic lattice, and the body-centred cubic lattice are considered. In the three-dimensional calculations both the antiferromagnetic and ferromagnetic cases are considered as well as the coupling to an external magnetic field of various strengths. Good agreement is found where the results can be compared with the exact two-dimensional results, and in the three-dimensional case the results agree well with those obtained from series approximations in the regions where the series approximations are valid. The present method appears to give good results for the short-range order even very close to the critical temperature, but in this neighbourhood the long-range order estimate is crude. The computations were performed on a high-speed computer.

THE MECHANISM OF THE ELECTRICAL CONDUCTIVITY OF FERRO- AND ANTIFERROMAGNETIC SEMICONDUCTORS. See Abstr. 5009

5065 MAGNETIZATION OF IRON–NICKEL ALLOYS UNDER HYDROSTATIC PRESSURE.
J.S.Kouvel and R.H.Wilson.
J. appl. Phys. (USA), Vol. 32, No. 3, 435-41 (March, 1961).

Magnetization measurements were made on iron, nickel, and their alloys in hydrostatic pressures up to 3000 atm and in fields up to 12 000 Oe. The results of these room-temperature measurements, combined with Patrick's results on the pressure dependence of the Curie temperatures, indicate that $\sigma_0$, the saturation moment at 0°K, as well as $\theta$, the Curie temperature, is rapidly decreased by compression in the fcc alloys of about 30% Ni. This is in agreement with the recent low-temperature pressure measurements of Kondorsky and Sedov. For these alloys, both $\sigma_0$ and $\theta$ are decreasing with increasing Fe concentration. When the 30% Ni alloy is partially transformed to b.c.c., its $\sigma_0$ and $\theta$ rise to much higher values but its magnetization is much less pressure dependent. It is concluded that unlike the more simple ferromagnetic b.c.c. alloys, the f.c.c. Fe–Ni alloys have a coexistence of ferromagnetic and antiferromagnetic order, similar to that recently proposed for the Ni–Mn alloys.

5066 CAUSES OF THE INCREASE OF THE COERCIVE FORCE ON REDUCTION OF THE THICKNESS OF FERROMAGNETIC SHEETS. V.A.Zaikova and Ya.S.Shur.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 3, 350-8 (Sept., 1960). In Russian.

The increase of the coercive force with decrease of thickness of monocrystalline and polycrystalline sheets of silicon iron (3.5% Si) and Permalloy 78 was shown to be due to an increase of the magnetic leakage fields at the sample surface. A.Tybulewicz

5067 A FERROMAGNETIC CYLINDER IN A CONSTANT MAGNETIC FIELD.
P.Oshurkov, V.Kashcheev and L.Chestnykh.
Latv. PSR Zinat. Akad. Vestis (USSR), No. 8(157), 63-72 (1960). In Russian.

Deals with the magnetic induction B produced in a circular cylinder of ferromagnetic material placed in a uniform magnetic field directed along the axis of symmetry. Würschmidt (1925) had previously given expressions for B and I the intensity of magnetization, at a point distant x cm from the centre of the cylinder, measured along the axis. Using classical theory, the vector potential at any point whose cylindrical coordinates are x, r, $\phi$ is now found, and from it B, in the form of a series of ascending powers of x, with different values of the coefficients of $x^n$ from those of Würschmidt, A table of values of $B/B_0$, where $B_0$ is the induction at the centre, derived from the two theories and from experiment, respectively, is given for the special case when the length is three times the diameter, and the susceptibility is $\chi = 0.9$. N.Davy

STABLE-OSCILLATION CONDITIONS FOR THE MAGNETIC-FILM PARAMETRON. See Abstr. 4696

EFFECTS OF A MAGNETIC FIELD ON HEAT CONDUCTION IN SOME FERRIMAGNETIC CRYSTALS. See Abstr. 4972

5068 CALCULATION OF THE GROUND STATE OF AN ANTIFERROMAGNETIC MATERIAL WITH UNIAXIAL ANISOTROPY. A.Ts.Amatuni.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 3, 395-9 (1958). In Russian.

Using the method of elementary perturbations, the ground state of an antiferromagnetic material with an anisotropic exchange interaction is considered. It is shown, in particular, that at a definite threshold value of external magnetic field directed parallel to the anitotropy axis and at a definite ratio of anisotropy constants, the parallel magnetization jumps from zero to some final value, i.e. there is a first-order phase change. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 3, 13-19 (1958)].

5069 MAGNETIC PROPERTIES OF CHROMIUM BETWEEN 0° AND 350°C.
E.W.Collings, F.T.Hedgcock and A.Siddiqi.
Phil. Mag. (GB), Vol. 6, 155-8 (Jan., 1961).

The susceptibility–temperature curves of several Cr specimens of varying purity show a maximum at 39 ± 0.5°C. Electron spin resonance measurements indicate that the peak is not due to the presence of a sufficient amount of $Cr_2O_3$; it is hence a manifestation of antiferromagnetism of pure metallic chromium. E.P.Wohlfarth

# Magnetic Resonances

5070 EXPERIMENTAL DETERMINATION OF THE COMPONENTS OF THE PERMEABILITY TENSOR AND THE SPECTROSCOPIC SPLITTING FACTOR OF MgMn FERRITES IN THE MICROWAVE REGION. I. K.H.Gothe.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 298-306 (1960). In German.

A microwave magnetic resonance spectrometer is described. Some results for a polycrystalline specimen are given.

A.J.Manuel

5071 EFFECTS OF APPLIED ELECTRIC FIELDS ON PARAMAGNETIC RESONANCE IN CHROME ALUMS.
M.E.Browne.
Phys. Rev. (USA), Vol. 121, No. 6, 1699-1701 (March 15, 1961).

The paramagnetic resonance spectra of single crystals of potassium chrome alum and ammonium chrome alum were investigated in the presence of applied electric fields at 9.3 kMc/s in the temperature range 4-300°K. The measurements were made in an effort to detect the possible existence of a term of the form $\xi\mu_0\vec{\sigma}\cdot\vec{E}$ in the interaction Hamiltonian for an electron in an electromagnetic field. Such a term corresponds to the existence of an electron dipole moment and would result in a lifting of Kramers' degeneracy for a magnetic ion in a crystalline field. No such term was observed, and the upper limit on $\xi$ obtained was $\xi < 0.007$. A dependence of the dielectric loss on electric field was observed in both alums at microwave frequencies.

5072 ELECTRON PARAMAGNETIC RESONANCE IN CRYSTALS OF TRIPHENYLMETHANE DYES.
F.P.Chernyakovskii, A.E.Kalmanson and L.A.Blyumenfel'd
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 786-7 (Dec., 1960).
In Russian.

Reports electron spin resonance spectra of crystal violet, methyl violet, basic brilliant green, malachite green, fuchsin (basic and acidic forms), fluorescein (uranine), rhodamines, thymol- and phenolphthaleins, indigo carmine and Congo red. With the exception of non-coloured phthaleins, coloured potassium thymolphthalein and malachite green, all the spectra were sharp singlets without hyperfine structure. The electron spin resonance signal disappeared on dissolution of indigo carmine and crystal violet in water and alcohol. [English translation in: Optics and Spectrosc. (USA)].

A.Tybulewicz

5073 ELECTRON SPIN–LATTICE RELAXATION OF CHROMIUM IN MgO. J.G.Castle, Jr, and D.W.Feldman.
Phys. Rev. (USA), Vol. 121, No. 5, 1349-50 (March 1, 1961).

The effective spin–lattice relaxation time $T_1$ was observed for the ground-state multiplet of $Cr^{3+}$ in the cubic field of MgO. $T_1$ was observed to vary from 800 msec at 1.3° to 3.4 msec at 50°K. The direct process dominates below 4.2°K.

5074 ACOUSTIC SPIN RESONANCE IN METALS.
L.L.Myasnikov.
Akust. Zh. (USSR), Vol. 6, No. 3, 347-51 (1960). In Russian.

Discusses the production of nuclear magnetic resonance in metals by means of ultrasound; the classical analogue of this phenomenon is the magnetoacoustic effect in metals. Interaction of ultrasound with nuclei is assumed to be of quadrupole nature. Re-establishment of thermal equilibrium is due to interaction with local magnetic fields of the conduction electrons. The intensity and profile of the lines are discussed in terms of relaxation broadening. [English translation in: Soviet Physics–Acoustics (USA), Vol. 6, No. 3, 347-51 (Jan.-March, 1960)].

A.Tybulewicz

UPPER LIMIT TO ANISOTROPY OF INERTIAL MASS FROM NUCLEAR RESONANCE. See Abstr. 4245

SUSCEPTIBILITIES AND NEGATIVE KNIGHT SHIFTS OF INTERMETALLIC COMPOUNDS. See Abstr. 5062

5075 PROTON MAGNETIC RESONANCE STUDY OF POLYCRYSTALLINE $HCrO_2$.
J.A.Ibers, C.H.Holm and C.R.Adams.
Phys. Rev. (USA), Vol. 121, No. 6, 1620-9 (March 15, 1961).

A proton magnetic resonance study of polycrystalline $HCrO_2$ as a function of magnetic field and temperature is presented. $HCrO_2$ is paramagnetic, and electron paramagnetic dipole as well as nuclear dipole effects lead to line broadening. The lines are asymmetric, and over the range of field $470 \le H_0 \le 9400$ gauss and temperature $77° \le T \le 294°K$ the asymmetry increases with increasing $H_0$ and decreasing T. An isotropic resonance shift of ~0.03% to lower applied fields indicates a weak isotropic hyperfine contact interaction. The general theory of resonance shifts is used to derive a general expression for the second moment $M_{2p}$ of a polycrystalline paramagnetic sample and is specialized to $HCrO_2$. The theory predicts a linear dependence of $M_{2p}$ on $[H_0/(T+\theta)]^2$, where $\theta$ is the experimentally determined Curie–Weiss constant. The experimental second moment $M_{2p}$ conforms to the relation

$$M_{2p}' = (3.96 \pm 0.06) + (0.084 \pm 0.002)\,[H_0/(T + 276)]^2$$

in agreement with theory. Hence, the electron paramagnetic effect (slope) can be separated from the nuclear effects (intercept). The paramagnetic dipole effects provide some information on the particle shapes. The nuclear dipole effects provide some information on the motions of the hydrogen nuclei, but the symmetry of the O–H–O bond in $HCrO_2$ remains in doubt.

5076 STUDY OF THE PROTON MAGNETIC RESONANCE OF THE CRYSTALLINE SOLID PHASE OF AZOXYPHENOL DI-P-N-AMYL ETHER. R.Köhler.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 241-3 (1960). In German.

The second moment of the resonance fell from about 4 $G^2$ to 2.81 ±0.14 $G^2$ within about 0.5° C as the liquid crystals were cooled past their solidification point (75° C). During further cooling the second moment remained at this low value until, at 62.5° C, it rose sharply to about 17 $G^2$. Homologous ethers did not show narrowing on solidification. It is proposed that, on solidification, the microscopic ordering becomes essentially complete, accounting for the temperature independence of the second moment in the intermediate solid phase. The macroscopic order, however, ceases to be complete on solidification, even in fields of 11 000 G, as demonstrated by measurements in which the sample is rotated to varying extents about an axis perpendicular to that of the field. The lowering of second moment is ascribed to a decrease in the macroscopic order corresponding to an irregular distribution of molecules or of certain groups, the effect of which is not entirely cancelled by the usual increase in intermolecular exchange effects on solidification. The linebroadening at 62.5° C may be due to a lattice change or restriction of internal motion; its sudden onset and a probable increase in density below 62.5° C favour the first explanation.

J.Sheridan

5077 NUCLEAR QUADRUPOLE ABSORPTION IN INDIUM METAL. W.W.Simmons and C.P.Slichter.
Phys. Rev. (USA), Vol. 121, No. 6, 1580-90 (March 15, 1961).

The nuclear quadrupole resonance spectrum of indium metal was observed and studied over the temperature range 4° to 225°K. The four transition frequencies occur in ratios of 1:2:3:4, as expected from the crystal structure of indium. The lowest transition at 1.881 Mc/s (at 4.2°K) gives a quadrupole coupling constant of (45.19 ± 0.02) Mc/s. The root second moment of 18 kc/s is substantially greater than the 4 kc/s predicted from magnetic dipolar coupling among the nuclei, is temperature independent, but somewhat dependent on the sample. It is shown that for a pure quadrupole resonance, the pseudo-exchange coupling produces an exchange broadening. This mechanism is shown to contribute about 10 kc/s to the root second moment and predicts a Gaussian line shape, as observed. It is concluded that in some cases magnetic impurities must be present, but it is not known whether or not the narrowest line represents a natural width. The field gradient is computed assuming point ions and a uniform electron density by a technique that converges rapidly with distance, but the answer is too small by a factor of 3. It is argued that it is important to consider the valence electrons. The temperature dependence of frequency is very strong (a 23% decrease between 4° and 220°K), and unexplained. It appears to show that the field gradients cannot be computed assuming point ions and a smooth charge distribution. A resonance in the superconducting state is reported.

NUCLEAR QUADRUPOLE RESONANCE. REVIEW. See Abstr. 4742

# MECHANICAL PROPERTIES OF SOLIDS

5078 ELASTIC MODULUS OF AMORPHOUS NICKEL FILMS. S.Jovanovic and C.S.Smith.
. appl. Phys. (USA), Vol. 32, No. 1, 121-2 (Jan., 1961).

The bulge test method [see Beams, Structure and roperties of Thin Films. New York: John Wiley and Sons (1959) . 183] was used to determine some mechanical properties of morphous nickel–phosphorus alloys deposited from suitable ypophosphite solutions. The elastic modulus thus measured was ound to increase with the degree of recrystallization to approximately that of the rolled nickel foil. In addition, no creep was bserved in samples subjected to 80% of the bursting stress for 8 hours. R.Bullough

SOUND WAVES IN DEFORMED PERFECTLY ELASTIC IATERIALS. See Abstr. 4406

METHOD FOR THE DYNAMIC DETERMINATION OF THE LASTIC, DIELECTRIC, AND PIEZOELECTRIC CONSTANTS OF UARTZ. See Abstr. 5041

5079 THE ELASTIC MODULUS AND INTERNAL FRICTION OF ELECTRODEPOSITED COPPER.
.J.Read and A.H.Graham.
. Electrochem. Soc. (USA), Vol. 108, No. 1, 73-8 (Jan., 1961).

Describes experimental techniques and calculations for the etermination of elastic modulus and internal friction from sonic neasurements on thin-walled tubes prepared by electrodeposition. method of making the tubes with the neccessary precision is resented. Data on the effects of some plating variables are given, ut special attention is devoted to relationships between the tructures of the deposits and the elastic properties under study.

5080 STUDY OF THE BORDONI INTERNAL FRICTION PEAKS IN COPPER. V.K.Paré.
. appl. Phys. (USA), Vol. 32, No. 3, 332-40 (March, 1961).

The internal friction of several cold-worked copper single rystals was measured between 4° and 300° K at 4 kc/s. Vibrational train amplitudes ranging from $10^{-7}$ to $2 \times 10^{-5}$ were used. In pure amples the height of the Bordoni relaxation peak increased slightly ith strain amplitude, but in all samples the activation energy of the elaxation process was not affected. This conclusion may be reconiled with the theory of Donth — and some other aspects of the neasurements (e.g. peak width) can be clarified — by assuming that he dislocations participating in the relaxation process are under nternal stresses resulting from the prior cold work. An activation nergy of 0.12 eV is consistent with the present data, but the range f frequency represented in the comparison is not sufficient to determine the value accurately. It is shown that the subsidiary peak consists of two separate peaks at about 30° and 40° K.

5081 PENETRATION OF A SHARPENED AXIALLY-SYMMETRICAL BODY INTO SOILS. A.Ya.Sagomanyan.
Dokl. Akad. Nauk SSSR, Vol. 134, No. 6, 1320-3 (Oct. 21, 1960).
In Russian.

The problem of the penetration of a cone into soil is solved theoretically on the assumptions (1) that the solid can be regarded as a "plastic gas" (the density of the material increases on loading according to a definite law, but on unloading, the material conserves the density reached in the loading cycle); (2) that the particle motion is in planes parallel to the free surface; (3) that shock waves are propagated in these planes; (4) that the density changes only at a shock wave. On the basis of the solution, curves are given for the penetration velocity and acceleration as functions of the propagation depth. [English translation in: Soviet Physics — Doklady (USA)]. R.F.S.Hearmon

5082 THE SYSTEMATIC CHARACTER OF DEVIATIONS FROM PLASTICITY LAWS. N.M.Mitrokhin and Yu.I.Yagn.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 4, 796-9 (Dec. 1, 1960).
In Russian.

Nickel tubes of 8.1 mm diameter, 0.2 mm wall thickness, 165 mm long were subjected to different combinations of extension, twisting moment and internal pressure to give values of the stress deviator lying between −1 and +1. The stress–strain curves were found to depend systematically on the absolute value of the stress deviator. [English translation in: Soviet Physics — Doklady (USA)]. R.F.S.Hearmon

ELECTRIC EFFECT OBTAINED DURING PLASTIC DEFORMATION OF NaCl CRYSTALS. See Abstr. 5043

5083 THE FLOW STRESS OF METALS AT LOW TEMPERATURES. P.Feltham.
Phil. Mag. (GB), Vol. 6, 209-15 (Feb., 1961).

The collapse of narrow V-shaped notches formed in glide dislocations at points of close approach to dislocations threading the glide plane is shown to facilitate intersection without thermal activation. The force effecting intersection, which is a component of the line tension of the notches, subsequently assists the glide dislocation to overcome the drag of jogs formed in the process. A consequence of this dual function of the force is the Cottrell–Stokes law, i.e. the strain invariance at any given temperature and strain rate, of the ratio $\tau_T/\tau_G$, where $\tau_T$ and $\tau_G$ are the temperature dependent and independent parts of the flow stress respectively. Linear and parabolic work-hardening laws are deduced from the model. On equating the slip distance to grain size in the parabolic relation the flow stress is found to be linear in $(\text{grain size})^{-1/2}$, which is known to apply, for example, to zinc. The activation energy of the jog migration associated with $\tau_T$, estimated from low-temperature flow stress data, is equal to about $\frac{1}{3}$ eV in copper.

5084 CRACK PROPAGATION IN A STRAIN-CRYSTALLIZING ELASTOMER. E.H.Andrews.
J. appl. Phys. (USA), Vol. 32, No. 3, 542-8 (March, 1961).

The dependence of small-scale crack propagation in a strain-crystallizing elastomer (natural rubber) upon the applied strain was studied under conditions of cyclic deformation over a range of frequencies. During each cycle the crack propagates along a well-defined path, different from the axis of symmetry, which is identified as the locus of maximum stress in a stationary stress distribution (i.e. one which does not move with small advances of the crack). The stationary stress hypothesis also accounts for the quantitative dependence of crack growth upon the external constraint. It is shown that a stationary stress distribution could arise as a result of the severe mechanical hysteresis displayed by strain-crystallizing rubbers.

5085 RESIDUAL THERMOELASTIC STRESSES IN BONDED SILICON WAFERS. T.D.Riney.
J. appl. Phys. (USA), Vol. 32, No. 3, 454-60 (March, 1961).

The residual thermoelastic stresses produced in a silicon strip when eutectic bonded to a gold plated molybdenum block are investigated photoelastically using near infrared light and an image convertor tube. This is the two-dimensional analogue of a problem arising when silicon wafers are bonded to headers in semiconductor devices. It is first shown that, with the proper orientation of the crystal, the specimen may be studied by the methods normally employed with isotropic birefringent materials. This simplifies the quantitative evaluation of the stresses. It is found that, though the mean longitudinal stress near the centre of the strip is compressive, a transverse tensile stress of greater magnitude occurs near the ends of the strip.

# CRYSTALLOGRAPHY

5086 AN ASPECT OF ORDER IN THE PHYSICAL WORLD. E.L.Yates.
London: Oxford University Press (1961) 23 pp.

An inaugural lecture given in the University College of Rhodesia and Nyasaland. Discusses briefly the external form of ice and diamond crystals, atomic crystal structure of metals and alloys, order–disorder phenomena, short-range order, structure of liquids and amorphous solids, and dislocations.

5087 THE "BALLAS" FORM OF DIAMOND. R.B.Fischer.
Nature (GB), Vol. 189, 50 (Jan. 7, 1961).

A ballas form of diamond is sectioned and etched to determine its internal structure. It consists of polycrystalline mass without

any radial geometry. This ballas appears to be different from the classic hailstone boart and it is suggested that hailstone boart and ballas should not be confused. S.Tolansky

5088 TWIN STRUCTURES IN SILVER DENDRITES.
J.W.Faust, Jr and H.F.John.
J. Electrochem. Soc. (USA), Vol. 108, No. 1, 109-10 (Jan., 1961).

5089 HIGH-TEMPERATURE GASEOUS ETCHING OF GERMANIUM SINGLE CRYSTALS.
V.N.Maslov and L.V.Nabatova.
Kristallografiya (USSR), Vol. 5, No. 3, 470-2 (May-June, 1960). In Russian.

The {111} planes of single-crystal n-type Ge, resistivity 12-24 ohm cm, were polished then etched in chlorine or bromine, at a pressure slightly over atmospheric for times of 1-10 min over a temperature range of 2-700°C. The etching disclosed not only the dislocation etch pits produced by conventional chemical etches but also defects due to mechanical polishing. [English translation in: Soviet Physics — Crystallography (USA), Vol. 5, No. 3, 447-9 (Nov.-Dec., 1960)]. W.Bardsley

5090 THE GROWTH OF METALLIC SINGLE CRYSTALS UNDER HIGH HYDROSTATIC PRESSURES.
L.F.Vereshchagin, Yu.N.Ryabinin, A.Ya.Preobrazhenskii and V.A.Stepanov.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 1, 45-7 (Nov. 1, 1960). In Russian.

Two methods of growing single crystals of metals at high pressures are described. In one of these the pressure is variable and in the other constant. Crystals of aluminium and zinc were obtained in this way using a vertical graphite furnace. At pressures of 10 000 atm and at a temperature equal to the crystallization temperature, the growth rate was of the order of 0.5 mm/min. Specimens were also obtained at normal pressures with higher growth rates using the same furnace. [English translation in: Soviet Physics—Doklady (USA)]. K.N.R.Taylor

5091 STEP FORMATION DURING THE GROWTH OF $BaTiO_3$ CRYSTALS. R.C.DeVries and G.W.Sears.
J. chem. Phys. (USA), Vol. 34, No. 2, 616-18 (Feb., 1961).

The growth behaviour of barium titanate crystals from molten potassium fluoride at 1000°C may be described in some detail by the Frank growth mechanism. In particular the role of re-entrant twin angles as growth step sources was examined. A finite supersaturation is required for the operation of this source and the event must occur by an easier nucleation process than homogeneous two-dimensional nucleation.

5092 SOME OBSERVATIONS ON THE SYNTHESIS OF DIAMONDS. H.Liander and E.Lundblad.
Ark. Kemi (Sweden), Vol. 16, Paper 9, 139-49 (1960).

A brief review is given of techniques used for the production of synthetic diamond. The temperature—pressure equilibrium is discussed for diamond and graphite. Diamonds were produced by the precipitation of dissolved carbon in mixtures of iron carbide and iron. High pressures were used and high temperature was secured by thermite heating. Diamonds were also produced by electrical heating. A repetition of Hannay's experiments resulted in failure. Direct transition of graphite to diamond was found to be impossible. S.Tolansky

5093 ZONE LEVELING AND CRYSTAL GROWTH OF PERITECTIC COMPOUNDS.
D.R.Mason and J.S.Cook.
J. appl. Phys. (USA), Vol. 32, No. 3, 475-7 (March, 1961).

Homogeneous samples of peritectic semiconducting compounds have been prepared for optical and electrical characterization by combining zone levelling concepts with Bridgeman crystal growth techniques. Proper temperature distribution in the zone levelling equipment must be established on the basis of the phase diagram for the material, and by considering the rate process accompanying solidification and crystal growth. The ingots produced by this method are substantially uniform and homogeneous in composition, whereas normally frozen or Czochralski-grown crystals contain concentration gradients.

# CRYSTAL LATTICE STRUCTURES

AN ASPECT OF ORDER IN THE PHYSICAL WORLD.
See Abstr. 5086

5094 CHAMBER FOR X-RAY STUDY OF MONOCRYSTALS UNDER HIGH PRESSURE.
L.F.Vereshchagin, S.S.Kabalkina and V.V.Evdokimova.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 90-2 (May-June). In Russian.

A rotation chamber for the study of monocrystals under pressures up to 7000 kg/cm² was constructed. The pressure was created by a steel piston and benzine used as the pressure transferring liquid. The piston was fixed in the working position by a nut. The pressure was measured by means of a manganin pressure gauge. A rotation X-ray photograph of NaCl under the pressure of 4000 kg/cm² is presented. [English translation in: Instrum. exper. Tech. (USA), No. 3, 420-2 (May-June, 1958; publ. June, 1959)].

5095 STATISTICAL ESTIMATION OF THE AGREEMENT BETWEEN HYPOTHESIS AND EXPERIMENT IN THE COURSE OF DETERMINATION OF AN ATOMIC STRUCTURE. PHYSICAL SIGNIFICANCE. CRITERION OF THE COMPLETION OF REFINEMENT. A.Rimsky.
Bull. Soc. Franc. Mineral. Crist., Vol. 82, No. 10-12, 374-9 (Oct.-Dec., 1959). In French.

The usual test of agreement between calculated and observed structure factors ($F_C$, $F_O$) is replaced by one in which the closeness of fit to a linear relation between $F_C$ and $F_O$ is tested. A.R.Stokes

MOIRÉ PATTERNS FROM SUPERPOSED LATTICE SYSTEMS. STEREOSCOPIC CINEMATOGRAPHY. See Abstr. 4475

MODIFICATIONS OF P DUE TO HIGH PRESSURE.
See Abstr. 5134

5096 DIMOLYBDENUM CARBIDE.
R.J.Fries and C.P.Kempter.
Analyt. Chem. (USA), Vol. 32, No. 13, 1898 (Dec., 1960).

A 12 g sample of $Mo_2C$ was pressed at 50 tons/in² in a 0.5 in. pellet die and heated at 1950°C for 90 min in an atmosphere of helium. The subsequent analysis gave 93.82% Mo, 5.66% total carbon, 30 p.p.m. N and 195 p.p.m. O; free carbon was not detectable. The analysis therefore corresponds to $Mo_{2.06}C$. The results of a spectrographic analysis are given and the X-ray diffraction powder lines are listed with relative intensities and spacings. The parameters of the closed-packed hexagonal lattice are $a = 3.00281 \pm 0.00007$ A, $c = 4.72878 \pm 0.00041$ A. After correction for refraction errors the values are, respectively, 3.00292 and 4.72895 A giving an axial ratio of 1.575. The theoretical density (for one $Mo_2C$ per unit cell) is 9.167 g/cm³ at 25°C. J.Ibal

5097 THE CRYSTAL STRUCTURE OF $YAl_2$.
P.I.Kripyakevich.
Kristallografiya (USSR), Vol. 5, No. 3, 463-4 (May-June, 1960). In Russian.

X-ray powder diagrams were obtained of four Y—Al alloys containing, respectively, 8.78, 30.0, 42.1 and 57.3% by weight of Y. The first two gave the lines of Al and of a solid solution but the other two gave patterns which were different. The alloy with 57.3% had a f.c.c. lattice with $a = 7.827 \pm 0.002$ A. The intensities correspond to an $MgCu_2$ structure. The inter-atomic distances are Y—Y = 3.38, Al—Al = 2.86, Y—Al = 3.24 A. [English translation in: Soviet Physics—Crystallography (USA), Vol. 5, No. 3, 440-1 (Nov.-Dec., 1960)]. J.Ibal

5098 SOME STRUCTURAL DATA ON METALLIC PHASES. IV.
K.Schubert, M.Balk, S.Bhan, H.Breimer, P.Esslinger and E.Stolz.
Naturwissenschaften (Germany), Vol. 46, No. 23, 647-8 (1959). In German.

Lattice parameters, structure types and atomic coordinates are given very briefly for $Au_4Zr$, $Au_3Zr$, $Au_2Ti$, $Au_2Zr$, $Au_2Mn$, $AuMn_2$, AuMn(Mn), $AuZr_3$, $PtCuZn_2$, $Pt_3Ga_7$, $Pt_2Ge_3$, $PtGe_2$, $Fe_2GaGe$, CoGe, and RhSe. A.R.Stokes

5099 SOME STRUCTURAL DATA ON METALLIC PHASES. V.
K.Schubert, S.Bhan, W.Burkhardt, R.Gohle, H.G.Meissner, M.Pötzschke and E.Stolz.
Naturwissenschaften (Germany), Vol. 47, No. 13, 303 (1960). In German.

A list of structures of the following materials: $Zr_2Pd$, $ZrPd_2$, $ZrAl_2$, $MoAl_4$, $MoAl_5$, MnAl, $Fe_3Ga$, $Fe_{70}Ga_{30}$, $Pt_3Ga$, $Pt_5Ga_3$, $Rh_5Si_3$, $Rh_{58}Si_{42}$, RhSi, $Ir_3Si$, $Ir_2Si$, $Ir_3Si_2$, $Pt_3Ge$, $Pt_3Si$, $Pt_4Ga$, $Pt_2Si$, $Pd_3As$. J.Thewlis

5100 STRUCTURE OF A NEW ANTIFERROMAGNETIC $BiFeO_3$. A.I.Zaslavskii and A.G.Tutov.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 4, 815-17 (Dec. 1, 1960). In Russian.

X-ray powder photographs of $BiFeO_3$ show that the unit cell is nearly cubic with small rhombohedral distortion. The possible space groups are listed; the interplanar distances and the intensities are tabulated, and a description of the structure is given. [English translation in: Soviet Physics — Doklady (USA)]. R.F.S.Hearmon

# OTHER SOLID FORMS

5101 X-RAY DIFFRACTION STUDY OF LEAD SULFIDE—ARSENIC SULFIDE GLASSES.
J.I.Petz, R.F.Kruh and G.C.Amstutz.
J. chem. Phys. (USA), Vol. 34, No. 2, 526-9 (Feb., 1961).

The structures of arsenic sulphide glass, two synthetic glasses, $PbS{\cdot}5As_2S_3$ and $2PbS{\cdot}5As_2S_3$, and a natural glass, $5PbS{\cdot}3As_2S_3$, were studied by X-ray diffraction. Arsenic is found to have three sulphur neighbours in the first three glasses, just as in crystalline arsenic sulphide. The natural glass and crystalline lead sulphide are similar in that lead is situated in octahedral holes among closely packed sulphurs. The increased ratio of sulphur to arsenic in the natural glass results in four sulphur neighbours for each arsenic. The lead—sulphur distance is about 3.1 A, and that for arsenic—sulphur is about 2.3 A.

A METHOD FOR INVESTIGATING THE QUANTITATIVE ABSORPTION OF CRYSTAL POWDERS. See Abstr. 4452

# Surfaces . Films . Adsorption

5102 OXIDATION PHENOMENA ON GERMANIUM SURFACES. M.Green.
Progress in semiconductors. Vol. 4 (see Abstr. 5007 of 1961) p.35-62.

Review dealing with germanium surfaces possessing adsorbed oxygen or an oxide layer. One aim of the work is to relate the properties to electronic surface states; another is to develop procedures for preparing stable, reproducible germanium surfaces. The preparation and properties of clean germanium surfaces are initially considered. The interactions of oxygen with such clean surfaces — kinetics, logarithmic adsorption, slow take-up, thermal regeneration, heat of adsorption, electronic effects, and the mechanism of the process — are discussed. The final section deals with chemically etched germanium, which is invariably covered with an oxide layer. The thickness and nature of the oxide layer, oxygen take-up rate, electronic properties, electrochemistry and high-temperature oxidation are considered. 68 refs. J.B.Birks

5103 THERMAL ASPECTS OF THE GROWTH OF THIN FILMS BY VACUUM SUBLIMATION. G.Gafner.
Phil. Mag. (GB) (Eighth Ser.), Vol. 5, 1041-8 (Oct., 1960).

A quantitative estimate of the temperature of a continuous film during deposition by vacuum evaporation was made. For a thick substrate a film growing at a maximum rate of 1000 A/sec to a thickness of 10 000 A would show a maximum temperature rise of only 17°C. Large surface temperatures could only arise when the heat capacity of the substrate was small. The times taken for thin substrates to attain various surface temperatures for a range of deposition rates and surface emissivities was calculated and temperature increases of hundreds of degrees Celsius would only arise for deposition onto very thin substrates. The temperature of a three-dimensional aggregate during growth was considered. High surface temperatures could only occur in the earliest stages of growth when both deposition and surface migration rates were high. Calculation showed in the extreme case an aggregate temperature of less than 100°C above the surface temperature in $10^{-6}$ sec and 9°C after 1 sec. W.Steckelmacher

5104 METHOD OF MEASURING AND CONTROLLING EVAPORATION RATES DURING THE PRODUCTION OF THIN FILMS IN VACUUM. H.Schwarz.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 194-9 (Feb., 1961).

A new method and device are described for measuring the density in a vapour stream of any material that will be deposited on a suitable substrate in vacuum. For this purpose a "nude" ionization gauge is used. The new ionization method differs from others in that it discriminates between the ions of the vapour and those resulting from the background pressure in the vacuum system. The ionization gauge is placed over a hole in the substrate holder; this hole is periodically opened and closed by a shutter vibrating at a low frequency, so that the ion gauge receives a pulsed vapour stream and detects an alternating ion current superimposed on the direct ion current. A narrow-band amplifier amplifies only the alternating ion current of the frequency of the shutter vibrator. A current integrator may control the total amount of evaporated material. The ionization gauge used in this method can easily measure the total pressure when the filtering system is bypassed. Calibration curves are shown and a theory given. Sensitivities of the order of A/sec and lower have been obtained.

5105 ON THE FIELD DESORPTION OF MAGNESIUM, RUBIDIUM AND SILVER. H.Kirchner.
Ann. Phys. (Germany), Vol. 6, No. 5 - 6, 279 - 92 (1960). In German.

Describes measurements of the electric field strength, in vacuum, necessary to remove Rb, Mg, and Ag ions from a pointed single crystal of tungsten. This field strength was found to be of the same order for all three elements but increasing in the order listed. The values obtained were not temperature-sensitive in the range −193° to 25°C. Similar experiments with thin layers of tungsten oxide and carbide gave much lower extraction field strengths. A.E.I.Research Laboratory

# MICROSTRUCTURE EXAMINATION

*(By X-rays and Electron and Other Microscopes)*

5106 APPARATUS FOR THE INTEGRAL MOVEMENT OF THE SPECIMEN DURING X-RAY MICRO-ANALYSIS OF A MATERIAL. J.Tykva and F.Khol.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 4, 187-91 (1960). In German.

Describes a mechanical linear scanning system for moving a specimen of 2 cm or so in size systematically under the primary beam of a micro-focus X-ray tube. In this way an X-ray diffraction pattern can be obtained which is representative of the average condition of the surface of the specimen. It is claimed that previous methods of averaging, which depend on rotating the specimen, introduce non-linear scattering effects and so do not necessarily give a true average pattern. Typical X-ray patterns taken with the new mechanism show its advantages in metallurgical applications. A.E.I.Research Laboratory

5107 DOUBLE BRAGG X-RAY SCATTERING STUDIES OF POLYCRYSTALLINE METALS.
R.L.Wild, W.T.Ogier, L.M.Richards and J.C.Nickel.
J. appl. Phys. (USA), Vol. 32, No. 3, 520-4 (March, 1961).

Small-angle double Bragg X-ray scattering was used for the study of recrystallization kinetics and angular misorientation of the mosaic structure in cold-worked nickel and iron foil. The scattering measurements showed that short time recrystallization in nickel took place by growth of initial blocks with an activation energy of 2.2 eV. The use of a getter during the vacuum anneal increased the growth rate by a factor of 1000. Angular misorientation was found to be associated with work hardening in both nickel and iron.

# PHYSICAL CHEMISTRY

## THERMOCHEMISTRY . REACTIONS

5108 KINETICS OF THE REACTIONS OF ALKYL IODIDES WITH HI. S.W.Benson and E.O'Neal.
J. chem. Phys. (USA), Vol. 34, No. 2, 514-20 (Feb., 1961).

A re-examination of Ogg's data on the kinetics of the reactions of RI + HI → RH + $I_2$ where R = $CH_3$, $C_2H_5$ or n–$C_3H_7$, shows that the mechanism is a simple I-atom catalyzed, radical reaction with the steps

$$I + RI \underset{2}{\overset{1}{\rightleftharpoons}} R + I_2$$

$$R + HI \underset{3}{\rightarrow} RH + I.$$

The rate expression is

$$d(I_2)/dt = k_1k_3K^{1/2}(RI)(HI)/[k_2(I_2) + k_3(HI)],$$

where K is the equilibrium constant for dissociation of $I_2$. Values are obtained for $k_1$, and the inhibition ratio $k_3/k_2$ at one temperature and for $k_1k_3/k_2$ over a temperature range. Using some entropy estimates, values are deduced for $A_1$, $A_2$, $A_3$, and $A_4$ all of which seem quite reasonable and self-consistent. The difference ($E_3-E_2$) appears to lie between 0 and 2 kcal/mole while $E_1$ is in excess of the estimated endothermicity of reaction (1) by not more than 1.5 kcal mole. There seems to be good agreement with independent data on the kinetics of pyrolysis of alkyl and aryl iodides which also turn out to be I-atom catalyzed, radical reactions.

5109 REACTIONS OF OXYGEN WITH PURE TUNGSTEN AND TUNGSTEN CONTAINING CARBON.
J.A.Becker, E.J.Becker and R.G.Brandes.
J. appl. Phys. (USA), Vol. 32, No. 3, 411-23 (March, 1961).

Oxygen was made to flow at constant rates through a system consisting of a tungsten ribbon, an ion gauge, and a conventional mass spectrometer. The ion gauge recorded total pressures while the spectrometer recorded partial pressures of $O_2$, CO, $CO_2$, $H_2O$, and other gases. From the way these pressures changed with filament temperature and time, absolute rates were computed at which $O_2$ was converted to $WO_3$, CO, $CO_2$, and O or evaporated as $O_2$. The data show that the sticking probabilities, the adsorption and desorption energies, and the rates of reaction change drastically when all the surface tungsten atoms have made first valence bonds with the adsorbed species; they change again after second valence bonds have been completed. Other conclusions are: (1) On a clean W surface consisting of 311 and 411 planes and for oxygen concentrations less than $4 \times 10^{14}$ atoms/cm$^2$, the sticking probability is 0.14, the desorption energy is 4.6 eV, and the evaporation rate is proportional to $\theta_1^2$; for concentrations between $5\text{-}9 \times 10^{14}$ atoms/cm$^2$, the sticking probability is 0.04, the desorption energy is 2.3 eV, and the evaporation rate is proportional to $\theta_2^2$. (2) In the temperature range 1200-1600° K the rate of formation and evaporation of $WO_3$ increases with $p(O_2)$ and with T; the activation energy is 1.1 eV. (3) From 2000-2400° K the rate of $WO_3$ formation increases as $p(O_2)^{3/2}$ and it decreases with T. (4) Less than about 4% of $O_2$ molecules which strike the hot surface are converted to $WO_3$. Most of the molecules evaporate as $O_2$. Only above 2200° K is any oxygen evaporated as O. (5) No CO or $CO_2$ is generated if the tungsten is carbon free. (6) If the tungsten contains carbon, CO and $CO_2$ are formed if the surface is covered with a layer of oxygen and the temperature is high enough. Every carbon atom that diffuses to the surface is oxidized. The diffusion rate of carbon is proportional to the concentration gradient and increases exponentially with (1/T); the activation energy is 2.2 eV. (7) Tungsten can be made carbon free by glowing it at 2200° K in oxygen pressures near $10^{-6}$ mm for 10-60 hr.

5110 THE ELECTRONIC INTERCHANGE EFFECT AS A FIRST STAGE OF CHEMICAL REACTIONS BETWEEN METALS AND CHEMISORBED GASES.
R.Suhrmann and G.Wedler.
Z. Elektrochem. (Germany), Vol. 63, No. 7, 748-56; Disc., 756-7 (1959). In German.

Coincident investigation of change of electrical resistance and photoelectric yield of thin metal films (from evaporation in high vacua) by chemisorption of gases, indicates chemical bonding similar to that of chemical surface bonding. Carbon monoxide is found to be mostly bonded on Ni at 90° K with the negative covering outside, but with the metal electrons heavily strained in direction towards the molecules. At lower temperatures on Cu, however, the electron concentration is increased between the two parts, connected with a great displacement of the metal electrons towards the molecules and of molecule electrons towards the metal; on Bi the two types appear to be coincident. Nitrogen is chemisorbed on Ni in a manner similar to that of Co on Cu, but only at low temperatures and with weaker affinity. Nitrogen is somewhat dissociated at 293° K on tungsten, so that the negative covering shows outside. Oxygen on Ni and on W is dissociated at 90° K into atoms which are bonded with negative coverage outside, but on Bi the O-atoms form electron acceptors and the adsorbed O-molecules also observed diminish the work function of the Bi surface. Very weak adsorption of hydrogen occurs on Bi and is probably molecular, but on the d-metals, Ni and Pt, the hydrogen atoms and molecules lie side by side and the atoms may be chemisorbed as $H^-$ or dissociated into proton and electron, whereby penetration into the film surface is possibly greater on Pt than on Ni. The discussion which follows on covalent bonding indicates the necessity for further work.
H.H.Hodgs

5111 ELECTRICAL CONDUCTIVITY OF THE $MnO_2$ SEMICONDUCTOR [CATALYST] DURING OXIDATION OF C
Zh.P.Kachanova, V.V.Voevodskii and A.P.Purmal'.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 648-50 (Nov. 21, 1960). In Russian.

According to an earlier paper [Voevodskii, Problemy Kinetiki i Kataliza, Vol. 8, 97 (1955)] the catalytic process should be associated with a reversible excitation of the catalyst. A striking increase of the electrical conductivity during such a process was observed by Bielanski, Deren and Gabar [Biuletyn Polskiej Akademii Nauk, oddz. 3, Vol. 3, No. 4, 221; No. 9, 491 (1955)], the effect being, however, related to macrochemical changes of the specimens. The present paper describes a quantitative study of the effects without any distorting factors. It was found that, during catalytic oxidation of CO, the catalyst (n-type $MnO_2$) is in the state of electronic excitation, i.e. in a thermodynamical non-equilibrium state. In all cases a correlation was found between the rate of the process and the degree of non-equilibrium of the catalyst. [English translation in: Soviet Physics–Doklady (USA)].
F.Lachm

5112 CATALYTIC ACTIVITY OF P AND N TYPE GERMANIUM. W.H.Watson, Jr.
J. appl. Phys. (USA), Vol. 32, No. 1, 120-1 (Jan., 1961).

Using the Fredel–Craft reaction in its simplest form, involving the reaction between an organic halide and a benzene molecule, p type germanium was found to be catalytically active and to function as an electron acceptor with a maximum reactivity around $10^{17}$ acceptor atoms per gram. Unless the germanium was crushed in vacuum the catalytic activity was low.
W.Bardsl

# LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Vol. 64 (1961). Reprints of the List of Journals can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s.0d. post free. The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

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| Arbok Univ. Bergen mat.-nat. Ser. (Norway) | Årbok for Universitetet i Bergen. Mat.-Naturv. Serie (Formerly: Universitet i Bergen Arbok. Naturvitenskapelig Rekke<br>University of Bergen, Bergen. Distribution address: Karl Johansgt. 47, Oslo. |
| GT&E Res. Developm. J. (USA) | GT&E Research & Development Journal (Formerly: Sylvania Technologist)<br>General Telephone & Electronics Corporation, 730 Third Avenue, New York 17, N.Y. Subscription address: Bayside 60, New York, N.Y. |
| Internat. J. Heat Mass Transfer (GB) | International Journal of Heat and Mass Transfer<br>Pergamon Press, Headington Hill Hall, Oxford; 122 East 55th Street, New York 22, N.Y. |
| Internat. J. mech. Sci. (GB) | International Journal of Mechanical Sciences<br>Pergamon Press, Headington Hill Hall, Oxford; 122 East 55th Street, New York 22, N.Y. |
| Planet. Space Sci. (GB) | Planetary and Space Science<br>Pergamon Press, Headington Hill Hall, Oxford; 122 East 55th Street, New York 22, N.Y. |
| Plasma Phys.—Accelerators—Thermonuclear Res. (GB) | Plasma Physics—Accelerators—Thermonuclear Research (Journal of Nuclear Energy. Part C)<br>Pergamon Press, Headington Hill Hall, Oxford; 122 East 55th Street, New York 22, N.Y. |
| Proc. Math. Phys. Soc. UAR (Egypt) | Proceedings of the Mathematical and Physical Society of UAR (Formerly: Proceedings of the Mathematical and Physical Society of Egypt)<br>Faculty of Science, Cairo University, Orman Gardens, Giza. |
| Proc. Vibration Problems (Poland) | Proceedings of Vibration Problems<br>Polish Academy of Sciences. Institute of Basic Technical Problems. Distribution Centre for Scientific Publications, Pałac Kultury i Nauki, Warsaw. |
| Toshiba Rev. [Internat. Ed.] (Japan) | Toshiba Review [International Edition]<br>Tokyo Shibaura Electric Co., Tokyo |

NEW JOURNALS

| | |
|---|---|
| Beitr. Plasma Physik (Germany) | Beitrage aus der Plasma Physik.<br>Akademie-Verlag, Leipziger Strasse 3-4, Berlin, W.8.<br>Vol. 1, No. 1, dated 1960-61. |

CHANGE OF TITLE

| | |
|---|---|
| Proc. Math. Phys. Soc. Egypt | Proceedings of the Mathematical and Physical Society of Egypt<br>Title changed to: Proceedings of the Mathematical and Physical Society of UAR [Proc. Math. Phys. Soc. UAR] with issue dated No. 23, 1959. |
| Sylvania Technol. (USA) | Sylvania Technologist<br>Title changed to: GT&E Research & Development Journal [GT&E Res. Developm. J. (USA)] with first issue dated 1961. |
| Univ. Bergen Arbok (Norway) | Universitet i Bergen Årbok. Naturvitenskapelig Rekke<br>Title changed to: Årbok for Universitetet i Bergen. Mat.-Naturv.-Serie [Arbok Univ. Bergen mat.-nat. Ser.]. |

# ERRATA

Abstr. 993 (1961) line 4: for "cleared" read "cleaved"
Abstr. 2545, 2549 (1961) line 4: insert "2386" as abstract number
Abstr. 2990 (1961) line 3: for "L.P.Lukirskii" read "A.P.Lukirskii"
Abstr. 3275 (1961) line 3: for "G.A.Milechin" read "G.A.Milekhin"
Abstr. 3288 (1961) line 3: for "G.U.Kulikov" read "G.V.Kulikov"
Abstr. 3291 (1961) line 3: for "Y.A.Smorodin" read "Yu.A.Smorodin"
Abstr. 3346 (1961) line 5: for "G.I.Inozemtseva" read "O.I.Inozemtseva"
Abstr. 3972 (1961): insert Abstractor's signature "J.K.Skwirzynski" at end of abstract
Author Index (Feb., 1961): for "Vasil'evskii,J.S.", read "Vasil'evskii,V.S."

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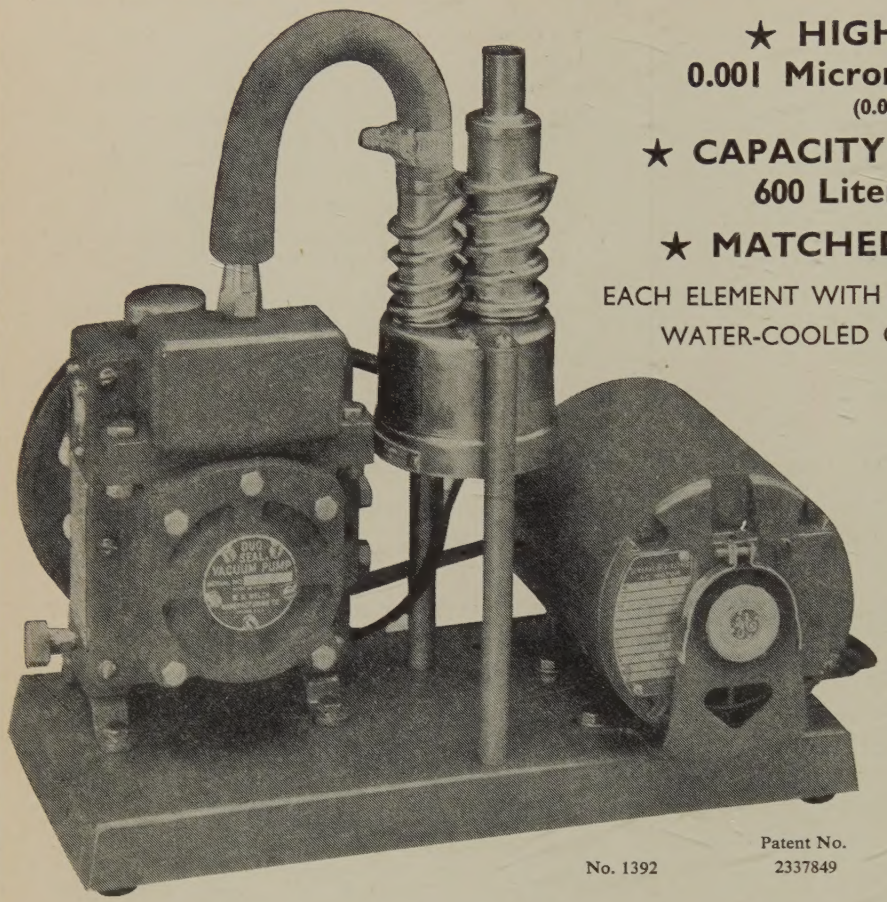

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